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TRANSMISSION LINE REFURBISHMENT STUDY
TOWER FOUNDATION INSPECTION AND TESTING
SMITH FALLS TO KINGSTON - 115 kV TL CCT S1K

Report No 88-183-K

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ABSTRACT

As part of the preliminary transmission line refurbishment study, an inspection and field load testing of foundations was conducted for Kingston type towers along a section of 115 kV cct S1K from Smith Falls to Kingston. The foundations were assessed for their condition, rate of aging and load capacity. The results of visual inspection, geotechnical investigation and field load tests of earth grillages and rock anchors are presented in this report. The variability associated with the foundation condition, corrosion of steel and load capacity are discussed. Factors contributing to the variability of the load capacity of foundations are highlighted. The foundation integrity and capacity are assessed based on the results of this study.

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TRANSMISSION LINE REFURBISHMENT STUDY
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1.0 INTRODUCTION

Over 11,000 circuit kilometers of 115 kV and 230 kV transmission lines were built prior to 1950. By the end of the century, these transmission lines will be at least 50 years old or more, which is the design life of the conductors and other line components. This initial phase of refurbishment study consisted of examining and testing the tower structure, foundations, conductors, insulators and hardware for a selected line. A section of a 115 kV line, built in 1928, south of Smith Falls in the Lennox to Merivale right-of-way was selected for this preliminary study. The foundations for the Kingston-type suspension towers (cct S1K) along this selected TL were assessed for their condition, rate of aging and the remaining strength. This foundation report contains the results of:

- visual inspection of tower footings
- geotechnical investigation
- field load tests in uplift and lateral shear
- excavation and inspection of test footings

2.0 TOWER FOUNDATION TEST PROGRAM

With the relocation of the old 115 kV circuit near Hinchinbrooke crossing (Figure 1), numerous cct S1K Kingston-type towers were declared surplus/1/. Two field trips were made to select suitable test towers and footings available for testing from the list of surplus towers. The selection was based on; (a) availability, (b) accessibility, (c) site conditions and (d) foundation type (earth grillage or rock anchors). Table I summarizes the various tower sites considered for field load tests. Figures 2 to 6 show general site conditions at several tower locations. Original design drawings, construction specifications and other details of the earth and rock footings are found elsewhere/2,3/.

2.1 Visual Inspection

2.1.1 Earth Grillages

Visual inspection of earth grillages was conducted before and after field load tests at selected sites where the tower was removed. Figure 7 depicts typical dimensions of excavated grillages.

Visual inspection of these footings included:

1. terrain and vegetation cover
2. corrosion inspection of steel members and connections buried at depth
3. checking footing dimensions and/or damaged members
4. soil sampling adjacent to the footing for laboratory testing
5. ground water conditions

A backhoe was used to excavate the footings. A hoe-ram attachment was required in some cases to break up the surface frost before excavation. Table II summarizes the footings extracted for inspection purposes.

The method of tower removal had damaged certain tower legs (Table II). Towers were removed by torching two legs and the tower pulled over onto its side. The total weight of the tower was supported on only two legs which caused them to buckle slightly. These deformed tower legs were used for inspection purposes only and no load tests were performed on them.

Excavation of three grillages at Tower #84 showed surficial rust on the main tower leg and bracing members at a depth of 0.3 to 0.6 m (Table II). In contrast, at Tower #143, more surficial rust was observed at a depth of 1.6 to 1.8 m on the grillage "mat" members (Table II).

Tower #83, which was thought to be on grillage foundations, upon excavation was found to have a rock anchor footing. A series of photographs in Appendix A documents the findings of excavated grillages. Laboratory corrosion measurements of the grillages were conducted by Metallurgical Research, the results of which are included in Appendix B. The corrosion evaluation of earth grillages will be discussed in Section 2.2.

2.1.2 Rock Anchors

Visual inspection was made of rock anchor foundations at a number of tower locations. Figure 8 shows the typical dimensions of a rock anchor foundation.

Visual inspection of the rock anchored footings was limited to above the bedrock contact which consisted of:

1. terrain and vegetation cover
2. ground water conditions

3. rock description and classification

4. footing dimensions and/or damaged members

5 corrosion of steel members and connections

6. concrete levelling pad

In order to investigate the integrity of the rock anchor below groundline, an attempt was made to recover the full length of rock anchor and grout column by overcoring at Tower #145. An "N-sized" core barrel (4 inch ID, 4 ft length) was used with a rotary drilling rig. Two partial samples were retrieved from Leg 1 and Leg 2. Surficial pitting (approximately 2-3 mm depth) and galvanization loss and discolouration was noticed just below the threaded portion of the rock anchor (Tower #145, Leg 2). A zone of concentrated corrosion of the steel appeared at the contact between the fractured/weathered limestone and concrete patchwork at the base of the tower leg. In contrast to this, the top of the rock anchor and the nut exposed above the groundline showed minimal corrosion. The rock anchor recovered from Leg 1, Tower #145, did not show visible signs of corrosion even though Leg 2 of the same tower did. The grout column encasing the rock anchor appeared to be in acceptable condition.

A series of photographs in Appendix A documents the condition of several rock anchor footings inspected. A laboratory corrosion assessment was made by Metallurgical Research on two rock anchors (Tower #145, Legs 1 and 2), the results of which are included in Appendix B. The corrosion evaluation of rock anchors will be discussed in Section 2.2.

2.2 Corrosion of Foundations

Corrosion of the foundation varied considerably from tower to tower along this line. Field inspection and subsequent sample recovery was necessary to assess the degree of corrosion and identify the controlling factors. The following general comments summarize the observations made to date (Appendix A and B).

1. The extent of foundation corrosion varied from a minimal to partial metal loss (ie reduction in cross-sectional area) at different tower sites.

2. The galvanization loss was concentrated at particular locations on the foundation (earth grillage or rock anchor).

3. Pitting was concentrated at/near the ground surface for rock anchors and bracing members.

4. Corrosion of grillages had occurred near the ground surface as well as at depth depending on the site and soil conditions.

5. No loss in structural strength was apparent from the observations made on several foundations, with the exception of Tower #151 where the bracing member suffered significant metal loss.

6. The nut and bolt connections showed only a surficial discolouration.

Soil analysis for corrosivity was performed on samples recovered adjacent to the grillages at the two tower sites (#84 and #143). The soil and site conditions at Tower 143 were more corrosive than at Tower #84. Examination of the tower footing steel at a shallow depth (0.6 m) below the ground surface would not have shown the measured difference in corrosivity at these two tower sites.

Further studies are planned to identify the prevalence, extent and causes of corrosion for other transmission lines in the province.

2.3 Soil Investigation

A detailed geotechnical investigation was performed at Towers #84 and 143 to assess:

1. extent and properties of the native soil and backfill material
2. strength parameters required for analysis of the field load tests

The field investigation consisted of:

(a) standard penetration tests
(b) dynamic cone tests
(c) dilatometer tests
(d) Shelby tube samples

The laboratory tests performed consisted of:

1. moisture content
2. natural density
3. soil classification
4. grain size analysis
5. unconfined compression test on cohesive samples

2.3.1 Site Conditions

The following is a summary of the soil conditions encountered at the test locations:

(a) Earth Grillages

Tower #84 was in an open field with a thin vegetation cover. The native soil was a loose to compact gravelly clay with occasional cobbles. The depth to bedrock was 1.8 m. The top 0.3 m was a loam/humus soil. The water table was at a depth of about 1 m.

Tower #143 was in an open pasture with a thin vegetation cover. Large rocks/boulders were piled around the base of the tower. The top 0.6 m was a loam/humus soil. The native soil, from 0.6 m to 2.4 m, was a loose to compact reddish brown silty sand. The water table was at a depth of 1.3 m below which caving conditions were encountered.

The results of the soil investigations for Towers #84 and #143 are contained in Appendix C.

Figure 9 shows the in situ testing of foundation backfill at Tower #143. The results of field and laboratory tests performed on the native and backfill materials are discussed in Section 2.3.2.

(b) Rock Anchor Foundations

Tower #145 was situated on a flat barren outcrop of weathered limestone. Extensive surficial fractures was evident. No further geotechnical investigation was conducted. Tower #151 was located on a fairly flat barren outcrop of weathered granite. Extensive/major surficial fractures were evident. Some vegetation and moss was present around the depression of Leg #3 (Appendix A). No further geotechnical investigation was conducted.

2.3.2 Summary of Soil Investigation

Figures 10 and 11 depict the grain size distribution of soil samples from Tower #84 and 143. Since the particle distribution curves for the native and backfill material appear similar, it can be concluded that the native soil was excavated during the grillage installation and was reused as the backfill material. Figure 12 depicts the delineations for frost-susceptible soils in comparison with the deposits found at Tower #84 and 143. Both tower locations have sufficient fine grain-sized content to be frost-susceptible. However, no visible signs of frost heave damage to the footings were observed at both tower locations.

Tables III to IX summarize the measured values for soil density, relative stiffness and the angle of friction of the native soil and backfill material.

Table III shows the dry density of the backfill material at Towers #84 and 143 determined from thin-walled Shelby tube samples. Standard Proctor tests were also performed on bagged samples from Towers #84 and 143. Table IV compares the average in situ dry density of the backfill material with the dry density obtained from a one-point standard Proctor compaction at its natural moisture content.

A comparison of the dilatometer modulus values obtained for the backfill and native soil gives an indication of the relative stiffness and hence the quality of backfilling operation done during grillage installation. A properly compacted granular backfill should not be looser than the native soil.

Tables V and VI summarize the strength properties of the native soil and backfill material in terms of the angle of friction measured by the dilatometer, standard penetration and dynamic cone tests. Table VII shows a difference in the average strength/angle of friction between the backfill material and native soil from the two sites. At both sites the backfill was looser than the native soil, indicating lack of placement control during the backfilling operation.

Tables VIII and IX summarize the average and standard deviation of the dilatometer modulus, Ed, for each test conducted in the backfill and native soil at Towers #84 and 143 respectively.

The following is a summary of the backfill material found at Towers # 84 and 143 based on the data presented so far:

(a) Tower #84 - Backfill Material

The backfill material was a loose to compact and well graded sand with cobbles and boulders (Unified Soil Classification - SW). The natural moisture content (14%) was near the optimum moisture content for compaction. The native soil was used as the grillage backfill material. The in situ density of backfill material was 20% less than the dry density obtained from the one-point standard Proctor. Therefore, this well-graded backfill material could be compacted further to increase the soil density by 20 per cent which will improve the soil strength and capacity of the foundation.

At Tower #84, the average Ed for the backfill ranged from 63 to 212 bars and the average Ed for the native soil was 159 bars (Table VIII). The relative stiffness of the backfill varied considerably compared to the native soil at Tower #84. The presence of coarse-sized particles (occasional cobbles/boulders and stones) may have affected the dilatometer results.

(b) Tower #143 - Backfill Material

The backfill material was a loose to compact and uniformly graded silty sand (Unified Soil Classification - SM). Its natural moisture content (22 to 25%) was close to its optimum moisture content for compaction. The backfill material found in the field was near the maximum dry density obtained from the one-point standard Proctor. However, this uniformly graded, fine-grained material is not well-suited for compaction as a backfill; in addition to being frost-susceptible.

At Tower #143, the average Ed for the backfill was 84 bars and the average Ed for the native soil was 183 bars (Table IX) indicating that the backfill was looser than the native soil.

At both tower locations (#84 and 143), the dilatometer modulus of the backfill was less than the native soil. This indicates that the backfill was not compacted as stiff as the native soil.

2.4 Field Load Test Set-Up

The set-ups used for the field load tests on earth grillages and rock anchors were as follows:

2.4.1 Grillage Footings

At each tower location (#84 and 143) one footing was excavated for visual inspection, prior to load tests, two grillage footings were tested in uplift and one footing was tested under lateral shear load. Details of the field load test set-up is given Appendix 11 of the grillages were excavated for inspection after load testing.

The test set-up for the uplift tests consisted of a pair of 10 m long steel beams resting on steel frame pads. A stacked pair of 534 kN (60 ton) hydraulic rams reacting against a steel seat was used to apply the loads as shown in Figure 13. The propane heater huts were built to thaw the surrounding soil mass and to eliminate frost-effects on-load test results. The load was applied in line with the stub of the tower leg to avoid bending. The loads were applied in increments of 10 kN and each increment was maintained for about 4 to 5 minutes or until most of the significant movements of the footing had occurred. The first test footing was loaded continuously to establish the ultimate capacity. For the second test footing, the load was cycled two times at approximately 25 and 50% of the anticipated capacity. At the final stages of loading each increment of load was maintained for 10 minutes or longer depending on the footing response. The loading was applied until the footing uplifted by 60 to 100 mm.

The movement of the soil mass around the test footing was monitored by tell-tale rods at different locations and depths as shown in Figure 14. The tell-tales consisted of of 6 mm steel rods in a PVC cased hole (25 mm diameter). The movement of the tell-tale rods was measured by micrometer dial gauges mounted on a remotely supported batter board. The ground heave and surficial cracks were recorded as the loading proceeded.

A lateral shear load test was performed on one footing at each tower location (#84 and 143). The stub leg of the test footing was pulled horizontally near groundline by a hydraulic ram reacting against a bulldozer (Figure 15). A dynamometer was used to measure the applied force of the hydraulic ram. The horizontal load was applied in increments of 2 kN until the horizontal displacement of the grillage stub at the groundline reached 150 mm. Figure 16 depicts the bending of the stub leg above groundline due to the horizontal load applied during testing.

All these grillage footings were excavated for examination of corrosion after the field load tests.

2.4.2 Rock Anchor Foundation

At each tower location (#145 and 151), two pairs of rock anchors were tested in uplift. Details of the field load test set-up are given in Appendix D/4/. The test frame set-up used for the uplift test consisted of a pair of 6 m long steel beams resting on steel frame pads. Two 890 kN (100 ton) hydraulic rams reacting against a steel seat were used to apply the loads as shown in Figure 17. Both rock anchors were loaded simultaneously while measuring the applied loads and anchor displacement. A special coupling adapter was used to connect the threaded end of the rock anchors to the pulling rods of the test frame (Figure 17). The loads were applied in increments of 5 kN and each increment was maintained for 4 to 5 minutes or until all of the significant movement of the rock anchors had occurred.

The movements of the rock mass around the pair of rock anchors were monitored by tell-tale rods at various locations and depths (Figure 18). The movements of the tell-tale rods were measured by micrometer dial gauges mounted on a remotely supported batter board. All the test rock anchors were uplifted in excess of 50 mm to cause failure. Two rock anchors were partially recovered for examination of corrosion after the field load tests.

3.0 GRILLAGE TEST RESULTS

The details related to the earth grillage tests are documented in Appendix E which contains the site layout, instrumentation layout and tabulated results of the load-deflections. The following are the findings from the field load tests.

3.1 Earth Grillages

Figures 20 to 25 shows the load-deflection curves for each grillage footing tested. The dimensions of all the test footings were the same. The following observations can be made from the uplift test results (Figures 20 to 23).

1) The maximum uplift capacity for Leg 4 at Tower #84 was 130 kN and at Tower #143, it was 50 kN.

2) The maximum uplift capacity obtained for Leg 2, Tower #84, was 140 kN and at Tower #143 it was only 58 kN.

3) Large displacements of the footing in excess of 50 mm were required to mobilize the maximum grillage capacity.

4) Upon load cycling at the two different stress levels, an additional displacement of 20 mm occurred due to soil creep.

Figures 24 to 27 show the soil movements measured during the uplift tests of the grillages at Tower #84 and Tower #143. The following observations can be made about the soil movements measured during the field load tests:

1) The soil movements observed at Tower #84 suggests the failure zone to be in the shape of an inverted truncated cone indicating a general mode of soil failure (Figures 24 and 25).

2) At Tower #143, a local bearing capacity type failure occurred in the backfill immediately above the grillage member (Figures 26 and 27).

3) The surrounding soil mass at Tower #143 showed no signs of movement. However, tell-tales #3 and 4 located directly above the grillage members indicated soil movements similar in magnitudes to the measured footing displacements which indicate localized soil failure.

The load-deflection response of grillages under a lateral shear loading are shown in Figures 28 and 29. The following observations can be made regarding a lateral shear loading test:

1) The lateral footing resistance increased non-linearly with the applied load.

2) The maximum lateral capacity measured at Tower #84 was 18 kN and at Tower #143 was 10 kN.

3) Large lateral groundline displacements in excess of 200 mm were required to mobilize the maximum lateral capacity.

4) Bending of the stub leg below the groundline occurred due to the applied lateral load.

3.2 Behaviour of Earth Grillages

The response of grillage foundations in different soil conditions can vary considerably. Several field load tests were performed in the past to identify the factors controlling the uplift capacity of grillage foundations. The results of previous grillage tests in various soil conditions are tabulated in Table X. From these studies it was concluded that the following factors control the uplift behaviour of grillage-type footings/5/:

(a) density of the backfill material
(b) ground water table and permeability of the backfill and surrounding soil
(c) relative density or shear strength of the backfill
(d) compressibility of the backfill

Table XI summarizes the grillage capacities as determined from the field load tests at Smith Falls in vertical uplift and lateral shear at Tower #84 and #143. A large variability was found in the uplift capacity of earth grillages at different site conditions. The ultimate uplift capacity, for the same sized grillage foundations, varied from 57 kN at Tower #143 to about 140 kN at Tower #84. This variability in the uplift capacity can be attributed to differences related to:

(a) the mode of failure of the grillage (ie general or local soil failure)
(b) variability of the native soil conditions
(c) variability of the backfill material placed over the grillages

A large uplift displacement of the grillage (in excess of 50 mm) was required to mobilize the ultimate capacity at both sites (Towers #84 and #143). The design uplift capacity of footings for different loading conditions ranges from 53 to 80 kN on Kingston-type towers. Considerable variability in the corresponding displacements at these two load levels occurred in the footings as follows:

(a) at Tower #143, for an applied load of 50 kN the uplift displacement ranged from 40 to 30 mm

(b) at Tower #84, the uplift displacement ranged from 10 to 15 mm for the same applied load of 50 kN.

(c) at Tower #84, for an applied load of 80 kN the uplift displacement ranged from 18 to 25 mm

(d) at Tower #143, the grillages could not sustain an applied load of 80 kN since the ultimate uplift was only 57 kN with a displacement in excess of 50 mm

In general, 12 mm of uplift displacement of the grillages corresponded to an average of 45 kN of applied load at both tower sites.

The variability in the footing responses observed between Tower #84 and #143 can be attributed to the factors related to the backfill density, strength and compressibility.

The bulk density of the backfill controls the magnitude of dead weight resisting the uplift of a grillage footing. A higher density of the backfill material proportionately increases the uplift capacity. However, below the ground water table, the unit weight of the backfill is effectively reduced due to buoyancy. In the case of semi-pervious and impervious soils (eg at Tower #143, silty sand), the total/bulk unit weight can be mobilized for the backfill for a rapid loading condition.

From the geotechnical investigation (Section 2.3.2), the measurements of density indicated that the backfill was less dense than the native soil. Therefore, the uplift capacity could be increased if the backfill material was compacted further. From the angle of friction measurements in Section 2.3.2, the backfill strength (angle of friction) was less than the native soil at both tower locations (#84 and 143). In addition to an increase in density, the strength properties of the backfill material also improves with compaction.

The compressibility of the backfill material directly above the grillage controls the magnitude of the footing displacement before the maximum uplift resistance is mobilized. Footings with uncompacted backfills exhibit large uplift movements due to soil compression upon loading. Furthermore, in very soft clays or very loose sands, local bearing failure in the soil above the grillage members may limit the maximum uplift capacity/5/. Differences in the modes of failure, eg: truncated inverted cone at Tower #84 or a local bearing failure at Tower #143, reflects the importance of the backfill compressibility.

The groundline lateral shear capacity also varied considerably between the two tower sites (Table XI). At Tower #84, the maximum lateral capacity was 18 kN and at Tower #143, the maximum lateral capacity was 9 kN. The lateral displacement of the grillage footing under maximum load was greater than 100 mm at both locations. The lateral resistance of the grillage footings corresponding to 12 mm movement was only about 2.5 kN.

4.0 ROCK ANCHOR TEST RESULTS

Documentation of the details related to the rock anchor foundation tests is presented in Appendix F which contains the site layout and instrumentation. All of the rock anchors consisted of a grouted smooth mild steel bar (25 mm diameter) with a wedge at the bottom.

A typical uplift test consisted of loading both rock anchors (left and right) simultaneously. Upon initial failure of one rock anchor, the applied load was released on both anchors. Subsequently each rock anchor was loaded individually to failure.

Figures 30 to 35 depict the load-deflection curves for all the rock anchors tested at Towers #145 and #151. Table XII summarizes the results of the rock anchor tests.

The load-displacement curves for these test anchors show the following:

(a) the maximum capacity was reached at about 12 mm of rock anchor displacement

(b) slippage occurred at the rock anchor-grout bond interface

(c) final failure of the rock anchor occurred by ductile yielding of the mild steel rod.

Figures 30 and 31 depict the described rock anchor behaviour at Tower #145. Figures 32 to 34 show a similar behaviour for the rock anchors at Tower #151. In all cases the left anchor failed before the right anchor during the field load test.

The following observations can be made from the results of the rock anchor tests:

(1) An average ultimate uplift capacity of 147 kN per anchor was obtained for the eight rock anchors tested.

(2) An uplift displacement of 12 mm was required to mobilize the maximum anchor capacity.

(3) The measured ultimate uplift capacity varied by a small amount from 134 kN at Tower #145 to 156 kN at Tower #151.

(4) The design uplift capacity per rock anchor of 25 to 40 kN for various tower loading conditions corresponded to an anchor displacement of less than 5 mm.

(5) Large slippage of the anchor rod occurred beyond the initial 12 mm of displacement under the maximum applied load.

(6) Final failure of the anchor was by ductile yielding of the steel rods as the wedge-type rock anchor "locked in place". All eight rock anchors were tested to failure by yielding of the steel rod with a total

displacement greater than 50 mm.

The measured capacity per anchor exceeded the design capacity significantly with a small variability in the anchor resistance.

Figure 35 shows the top portion of the rock anchor bolts recovered from the field load tests after the ductile failure of the rod. An average steel anchor rod deformation of 13 mm occurred due to ductile yielding of the rock anchor just prior to final failure (Table XIII). The rod yielding was observed in all cases as shown by the load-deflection curves (Figures 30 to 34).

5.0 CONCLUSIONS

A comprehensive investigation of several foundations was performed along a 115 kV transmission line (cct S1K) with Kingston-type towers. The investigation consisted of: (a) visual inspection of tower footings, (b) geotechnical investigation, (c) field load tests in uplift and lateral shear and (d) excavation and inspection of test footings.

Field inspections and testing showed a marked variability in the foundation condition and its load capacity, due to varying site and soil conditions along the selected towerline, especially in the case of earth grillage footings.

The geotechnical investigation identified differences between the native soil and backfill material for earth grillages. Quality control of the backfill during placement is important since it directly affects the uplift capacity of the grillage footing.

A properly compacted backfill offers advantages of:

(a) increased unit weight contributing to an increase in the uplift capacity

(b) increased stiffness of backfill reducing the footing displacements

(c) enhanced drainage around tower leg which will possibly reduce ponding and hence less corrosion of steel

The corrosion of grillage footings was found to be a function of the surface drainage conditions and the corrosivity of the soil around the footing. The zone and intensity of corrosion varied from location to location. At some locations the grillage buried at depth often showed indications of corrosion activity. Inspection of tower legs by shallow pits may not disclose such deep seated corrosion activity. A more comprehensive corrosion survey in a variety of soil conditions is needed to assess the controlling factors.

In the case of rock anchors, the corrosion was localized at the interface between the bedrock surface and the concrete patch surrounding the base connection.

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TABLE I

TOWER SITES ASSESSED FOR LOAD TESTING

Tower No	Location	Comments	Suitability for Testing: Tower and Foundation	Suitability for Testing: Foundation Only	Suitability for Testing: Foundation Type
(34-41)	near Forfar Tap	- no public access roads to site - in swamp	?	?	B
96 (65)	near Hinchbrooke Crossing	- open field	OK	OK	B
97 (66)	near Hinchbrooke Crossing		OK	-	B
98 (67)	near Hinchbrooke Crossing	- open field	OK	-	B
115 (85)	between Forfar Tap and Hinchbrooke Crossing	- towers removed with foundation left - in open field	-	-	B
116 (84)	between Forfar Tap and Hinchbrooke Crossing	- towers removed with foundation left - in open field	-	OK	A
117 (83)	between Forfar Tap and Hinchbrooke Crossing	- towers removed with foundation left - in open field	-	OK	A
127 (96)	near Hinchbrooke Crossing	- open field	N/A	N/A	A
128 (97)	near Hinchbrooke Crossing	- open field	N/A	N/A	A
129 (98)	near Hinchbrooke Crossing	- in switching yard	N/A	N/A	A

TABLE I (Cont'd)

Tower No	Location	Comments	Suitability for Testing Tower and Foundation	Foundation Only	Foundation Type
269 & 435	near Hinchbrooke Crossing	- not seen at Hinchbrooke Crossing site	?	?	?
106 (137) and 107 (138)	Jones Falls	- on rock outcrop - tower to be removed Jan 28/88	N/A	OK	A
112 (143)	near Jones Falls	- on rock outcrop - tower to be removed	N/A	OK	A
175 (144)	near Jones Falls	- on rock outcrop - open field	OK	-	B
175A (145)	near Jones Falls	- on rock outcrop - tower still there	N/A	OK	B
180 (150)	Point "D"	- tower still there - rock outcrop	N/A	N/A	B
181 (151)	Point "D"	- excessive corrosion of bracing on tower leg	N/A	OK	B
182 (152)	Point "D"	- rock outcrop - tower to be removed	N/A	OK	B
(216)	on Conc. Rd #12 east of County Rd #11	- farmer's field - tower leaning about 0.3 m S.E.	N/A	N/A	A
(224)	by County Rd #11 south of Washburn Rd	- low area of open field - tower leaning to N.W. about 0.6 m	N/A	N/A	A
(249)	south of Glenbarnie Rd (County #3) on McKendry Rd	- open field - possibly leaning to N.E.	N/A	N/A	A

TABLE I (Cont'd)

Tower No	Location	Comments	Suitability for Testing: Tower and Foundation	Suitability for Testing: Foundation Only	Suitability for Testing: Foundation Type
(250)	south of Glenbarnie Rd (County #3) on McKendry Rd	- open field - tower leaning S.E. about 0.3 m	N/A	N/A	A
(251)	south of Glenbarnie Rd (County #3) on McKendry Rd	- open field - tower leaning to S.E. - ponding around 4 tower legs	N/A	N/A	A

NOTE: (A) - Grillage foundation suspected
(B) - Rock anchors
Tower number with brackets seen in field tower structure
Tower number without brackets shown on profile drawing #7334 ET - Profile Smith Falls to Kingston Transmission Line, Mile 0 to Mile 29, July 20, 1928

TABLE II

EXCAVATED GRILLAGES FOR INSPECTION

Tower No	Leg No	Embedment Depth (m)	Time of Excavation	Comments
84	3*	1.60	before load test	- surficial corrosion at 0.3 to 0.6 m below ground surface on main leg and bracing - surficial rust on nuts and bolts
	1*	1.90	after lateral shear test	- surficial corrosion at 0.3 to 0.6 m below ground surface on main leg and bracing - surficial rust on nuts and bolts
	2	1.90	after uplift test	- surficial corrosion at 0.3 to 0.6 m below ground surface on main leg and bracing - surficial rust on nuts and bolts
143	1*	1.80	before load test	- caving condition at 1.3 m depth in loose to compact silty sand - surficial rust at depth of 1.8 m on grillage "mat" members - surficial rust on nuts and bolts
	3*	1.70	after lateral shear	- caving condition at 1.3 m depth in loose to compact silty sand - surficial rust at depth of 1.8 m on grillage "mat" members - surficial rust on nuts and bolts
	4	1.40	after uplift test	- caving condition at 1.3 m depth in loose to compact silty sand - surficial rust at depth of 1.8 m on grillage "mat" members - surficial rust on nuts and bolts

TABLE II (Cont'd)

Tower No	Leg No	Embedment Depth (m)	Time of Excavation	
83	3*	1.32	before load tests	- surficial corrosion on main leg and bracing members at depth 0.6 to 1.0 m in humus topsoil layer - not grillage but footing loose (6 mm gap between bearing plate and single rock anchor. Nut was tightened by 3/4 turn with wrench)
	4**	-	-	

NOTE: * Tower leg ben-t/buckled due to tower removal method
** Not excavated

TABLE III

DENSITY MEASUREMENTS OF GRILLAGE BACKFILL MATERIAL

TOWER NO.	SAMPLE NO. *	DEPTH (m)	MOISTURE CONTENT (%)	WET DENSITY (kg/m3)	DRY DENSITY (kg/m3)
143	BH8	1.5	22	2000	1639
84	BH1	1 - 1.6	16	1631	1404
84	BH2	0.6 - 1.6	15	1911	1665
84	BH2	0.6 - 1.6	18	1820	1549
84	BH6	0.6 - 1.6	15	1950	1691
84	BH6	0.6 - 1.6	16	1495	1288
84	BH9	1 - 1.3	16	1797	1552
143 LEG 3	BAG **	1.5 - 1.8	25	1985	1587
84 LEG 2	BAG **	1.5 - 1.8	14	2174	1902

NOTE: (*) SHELBY TUBE SAMPLES
(**) STANDARD PROCTOR TEST PERFORMED ON BAGGED SAMPLES

TOWER 143 LEG 3 BAG SAMPLE - 2 TO 3% OVER OPTIMUM WATER CONTENT
TOWER 84 LEG 2 BAG SAMPLE - NEAR OPTIMUM WATER CONTENT

TABLE IV

SUMMARY OF RESULTS
GRILLAGE BACKFILL DENSITY MEASUREMENTS

TOWER NO.	RANGE IN DRY DENSITY * (kg/m3)	AVERAGE DRY DENSITY * (kg/m3)	MAXIMUM DRY DENSITY ** (kg/m3)
143	-	1639	1587
84	1288 - 1691	1524	1902

NOTE: (*) UNDISTURBED SHELBY TUBE SAMPLES TAKEN IN THE FIELD
(**) ONE POINT STANDARD PROCTOR PERFORMED ON BAG SAMPLE

TABLE V

STRENGTH PROPERTIES OF NATIVE AND BACKFILL MATERIAL

TL REFURBISHMENT - SMITH FALLS
GEOTECHNICAL INVESTIGATION
SUMMARY OF RESULTS

TOWER NO.	TEST MATERIAL	ANGLE OF FRICTION * (degrees)	ANGLE OF FRICTION ** (degrees)
84	BACKFILL	30	< 28
84	BACKFILL	31	< 28
84	BACKFILL	34	< 28
84	BACKFILL	36	< 28
	AVERAGE	33	~ 28

TOWER NO.	TEST MATERIAL	ANGLE OF FRICTION * (degrees)	ANGLE OF FRICTION ** (degrees)
84	NATIVE	32	28
84	NATIVE	-	34
84	NATIVE	-	29
84	NATIVE	-	33
	AVERAGE	32	32

NOTE: (*) ESTIMATED BY DILATOMETER
(**) ESTIMATED BY STANDARD PENETRATION TEST AND DYNAMIC CONE

TABLE VI

STRENGTH PROPERTIES OF NATIVE AND BACKFILL MATERIAL

TL REFURBISHMENT - SMITH FALLS
GEOTECHNICAL INVESTIGATION
SUMMARY OF RESULTS

TOWER NO.	TEST MATERIAL	ANGLE OF FRICTION * (degrees)	ANGLE OF FRICTION ** (degrees)
143	BACKFILL	29	< 28
143	BACKFILL	29	< 28
143	BACKFILL	30	< 28
143	BACKFILL	31	< 28
143	BACKFILL	29	28
143	BACKFILL	31	28
	AVERAGE	30	~ 28

TOWER NO.	TEST MATERIAL	ANGLE OF FRICTION * (degrees)	ANGLE OF FRICTION ** (degrees)
143	NATIVE	32	30
143	NATIVE	31	33
143	NATIVE	31	33
	AVERAGE	31	32

NOTE: (*) ESTIMATED BY DILATOMETER
(**) ESTIMATED BY STANDARD PENETRATION TEST AND DYNAMIC CONE

TABLE VII

STRENGTH PROPERTIES OF NATIVE AND BACKFILL MATERIAL

TL REFURBISHMENT - SMITH FALLS
GEOTECHNICAL INVESTIGATION
SUMMARY OF RESULTS

TOWER NO.	TEST MATERIAL	AVERAGE ANGLE OF FRICTION * (degrees)
84	BACKFILL	28
84	NATIVE	32
143	BACKFILL	29
143	NATIVE	32

NOTE: (*) AVERAGE ANGLE OF FRICTION BASED ON DILATOMETER, STANDARD PENETRATION TEST AND DYNAMIC CONE DATA

TABLE VIII

SUMMARY OF RESULTS
DILATOMETER MODULUS, Ed, DATA FOR THE NATIVE AND BACKFILL MATERIAL

TOWER NO.	LEG NO.	BOREHOLE	MATERIAL TESTED	AVERAGE * ED (BAR)	STANDARD * DEVIATION OF Ed (BAR)
84	LEG 4	D-1	BACKFILL	131	87
84	LEG 4	D-2	BACKFILL	212	50
84	LEG 1	D-3	BACKFILL	63	14
84	LEG 2	D-4	BACKFILL	161	125
84	-	D-5	NATIVE	154	61

NOTE: (*) AVERAGE AND STANDARD DEVIATION OF Ed CALCULATED FOR BOREHOLE DEPTHS 0.65 TO 1.65 m

TABLE IX

SUMMARY OF RESULTS
DILATOMETER MODULUS, Ed, DATA FOR THE NATIVE AND BACKFILL MATERIAL

TOWER NO.	LEG NO.	BOREHOLE	MATERIAL TESTED	AVERAGE * Ed (BAR)	STANDARD * DEVIATION OF Ed (BAR)
143	LEG 2	D-1	BACKFILL	85	31
143	LEG 2	D-2	BACKFILL	63	21
143	LEG 4	D-3	BACKFILL	51	32
143	LEG 4	D-4	BACKFILL	115	48
143	LEG 3	D-5	BACKFILL	123	48
143	LEG 3	D-6	BACKFILL	66	50
143	-	D-7	NATIVE	206	50
143	-	D-8	NATIVE	161	21
143	-	D-9	NATIVE	181	39

NOTE: (*) AVERAGE AND STANDARD DEVIATION OF Ed CALCULATED BOREHOLE DEPTHS 0.65 TO 1.85 m

TABLE X

SUMMARY OF RESULTS
PREVIOUS UPLIFT TESTS ON GRILLAGE FOUNDATIONS/5/

TEST SITE		GROUND WATER LEVEL (m)	BACKFILL DENSITY (kg/m3)	GRILLAGE DIMENSIONS			MAXIMUM UPLIFT LOAD (KN)	MAXIMUM UPLIFT (mm)	LOAD AT 25 mm UPLIFT (KN)
				DEPTH (m)	WIDTH (m)	LENGTH (m)			
Brantford Twr #35	Loose Sand	2.5	1576	2	1 m DIAMETER		134.0	64	82
Brantford Twr #36	Loose Sand	1.4	1845	2.1	1.2	1.8	182.0	50	160
Cawthra Rd Twr #2	Clayey Silt Till	-	1960	2.1	1.2	1.8	374.0	200	184
Ottawa Twr #168	Soft Clay	-	1992	4.1	1.2	1.8	250.0	85	185
London * Twr #520	Dense Till	-	2240	2.2	2.0	2.0	540.0	85	480

NOTE (*) GRILLAGE WAS ENCASED WITH A 0.3 m CONCRETE PAD

TABLE XI

FIELD LOAD TESTS ON GRILLAGES AT SMITH FALLS

TOWER NO.	LEG NO.	TYPE OF FDN. TEST PERFORMED	ULTIMATE CAPACITY (KN)	FAILURE * CAPACITY (KN)	MODE OF FAILURE
84	2	UPLIFT	144.6	56.1	TRUNCATED CONE
84	4	UPLIFT	136.2	47.2	TRUNCATED CONE
143	2	UPLIFT	56.9	35.6	LOCAL BEARING FAILURE
143	4	UPLIFT	57.9	33.4	LOCAL BEARING FAILURE
84	1	LATERAL SHEAR	17.8	2.4	BENDING OF STUB LEG
143	3	LATERAL SHEAR	8.9	< 3.6	BENDING OF STUB LEG

NOTE : (*) FAILURE CAPACITY AT 12 mm DISPLACEMENT OF GRILLAGE

TABLE XII

ROCK ANCHOR UPLIFT LOAD TESTS

		LEFT ROCK ANCHOR		RIGHT ROCK ANCHOR		
TOWER NO.	LEG NO.	ULTIMATE CAPACITY (KN)	FAILURE * CAPACITY (KN)	ULTIMATE CAPACITY (KN)	FAILURE * CAPACITY (KN)	MODE OF FAILURE
145	1	144.6	-129	149.1	-116	(L) - ANCHOR FAILED IN TENSION (R) - ANCHOR FAILED IN TENSION AFTER SLIPPAGE > 50 mm
145	2	149.1	-134	153.5	-111	(L) - ANCHOR FAILED IN TENSION AFTER SLIPPAGE > 50 mm (R) - ANCHOR FAILED IN TENSION
151	1	149.1	-102	135.7	-107	(L) - ANCHOR FAILED IN TENSION AFTER SLIPPAGE OF 38 mm (R) - ANCHOR FAILED IN TENSION AFTER SLIPPAGE OF > 100 mm
151	2	149.1	-102	144.6	-111	(L) - ANCHOR FAILED IN TENSION AFTER SLIPPAGE OF 38 mm (R) - ANCHOR FAILED IN TENSION AFTER SLIPPAGE OF 50 mm

NOTE : (*) FAILURE CAPACITY AT 6 mm DISPLACEMENT OF ROCK ANCHOR
(L) - LEFT ROCK ANCHOR OF THE PAIR
(R) - RIGHT ROCK ANCHOR OF THE PAIR

TABLE XIII

DEFORMATIONS AND YIELDING OF ROCK ANCHOR RODS

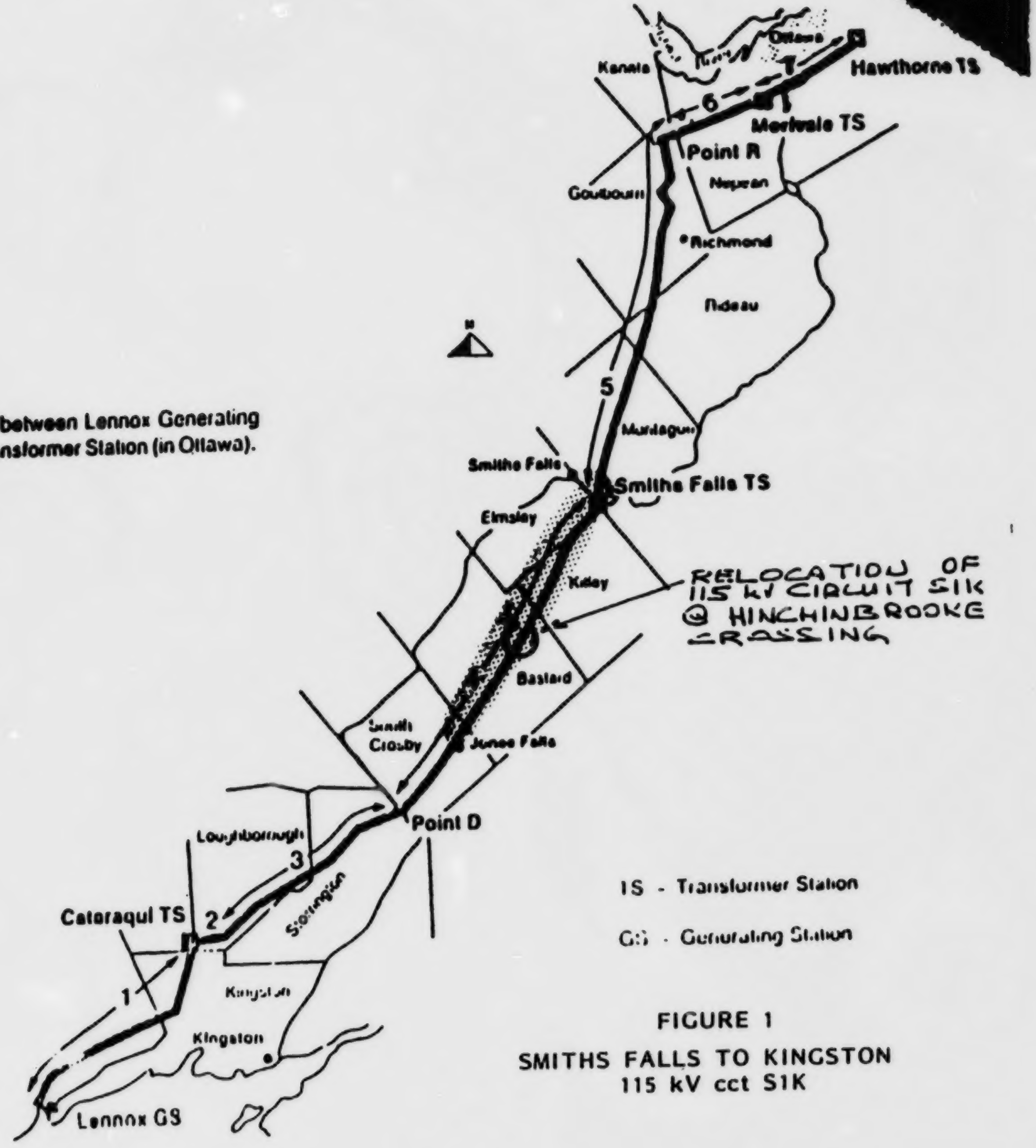
TOWER NO. (1)	LEG NO. (2)	NO. OF THREADS (3)	STRETCHED LENGTH (mm) (4)	TOTAL STRETCH OF ROD (mm) (5)	DEFORMATION OF ROD TO FAILURE (mm) (6)
145	LEG 2 LEFT	4	10	20	7.5
145	LEG 2 RIGHT	4	13	26	13.5
145	LEG 1 LEFT	4	12	24	11.5
145	LEG 1 RIGHT	4	15	30	17.5
151	LEG 1 LEFT	4	15	30	17.5
151	LEG 1 RIGHT	4	10	20	7.5
151	LEG 2 LEFT	4	12	24	11.5
151	LEG 2 RIGHT	4	15	30	17.5
					AVERAGE 13 mm STD. DEV. 4 mm

ROCK ANCHOR DIMENSIONS: DIAMETER 25 mm
EMBEDDED LENGTH APPROXIMATELY 1.3 m (4 ft.)
8 PITCH PER INCH OR 3.125 mm/PITCH
MECHANICAL WEDGE-TYPE ROCK ANCHOR
MILD STEEL (YIELD STRENGTH APPROXIMATELY 30 KSI)

NOTE : Col. (1,2,3,4) TOP THREADED PORTION OF ROCK ANCHOR ONLY
(5) TOTAL YIELDING OF ROD APPROXIMATELY TWO TIMES THE TOP PORTION OF THE ROD
(6) DIFFERENCE IN YIELDED LENGTH AND INITIAL LENGTH

Eastern Ontario Study
(Lennox GS to Hawthorne TS)
Right of Way Cross Sections

- Two parallel 500 kilovolt transmission lines between Lennox Generating Station (west of Kingston) and Hawthorne Transformer Station (in Ottawa).
- 188 kilometre long right-of-way.
- First line in service - 1989
  Second line in service - 1990's


Ottawa
Kanata
Hawthorne TS
6
7
Merivale TS
Point R
Nepean
Goulbourn
Richmond
Rideau
N
5
Montague
Smiths Falls
Smiths Falls TS
Elmsley
Kitley
RELOCATION OF
115 kV CIRCUIT S1K
@ HINCHINBROOKE
CROSSING
Bastard
South Crosby
Jones Falls
Point D
Loughborough
3
Storrington
Cataraqui TS
2
1
Kingston
Kingston
Lennox GS

TS - Transformer Station

GS - Generating Station

FIGURE 1

SMITHS FALLS TO KINGSTON
115 kV cct S1K

FIGURE 2

TOWER # 66 (NEAR SMITH'S FALLS)

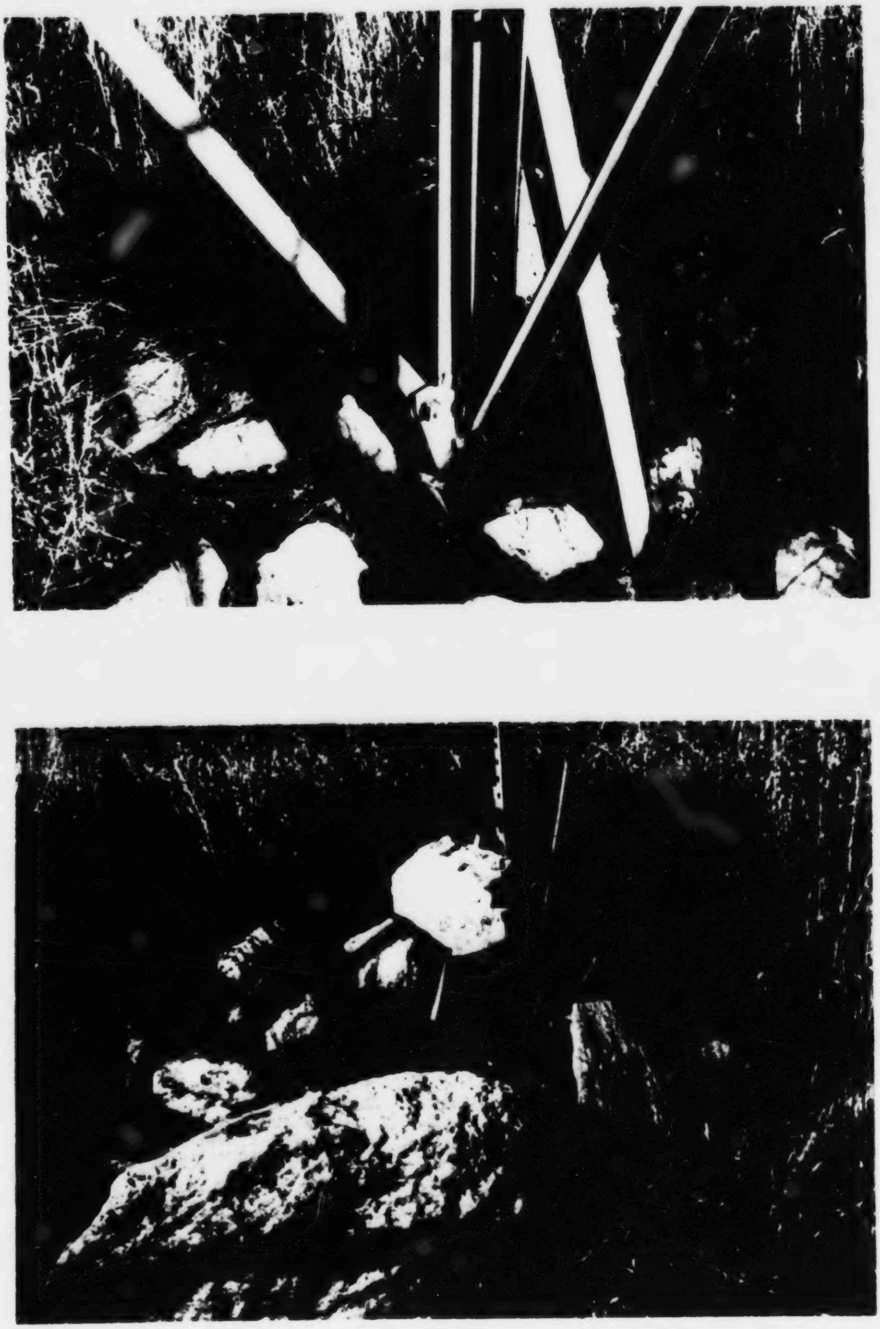
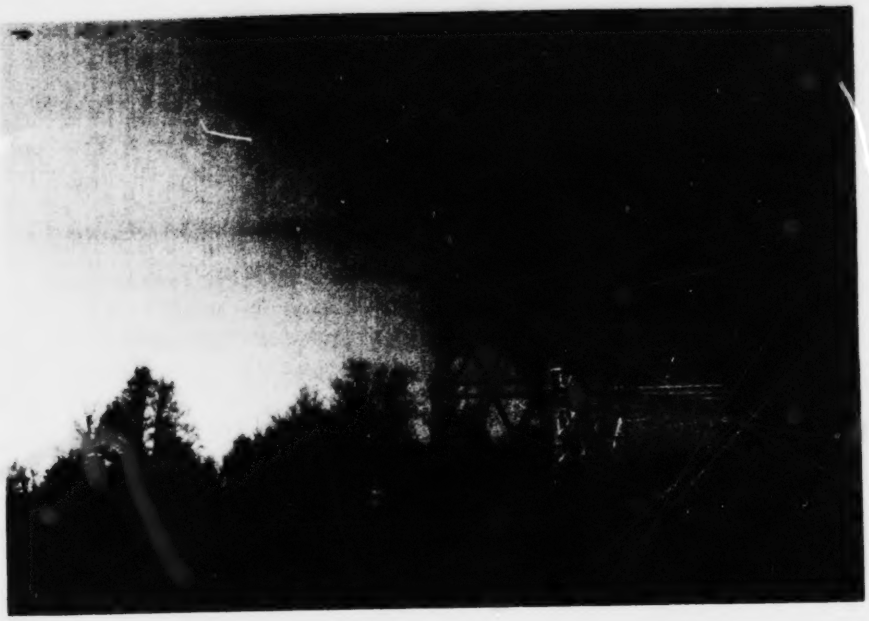


FIGURE 3

TOWER # 66
BOULDERS SCATTERED AT BASE OF THE TOWER



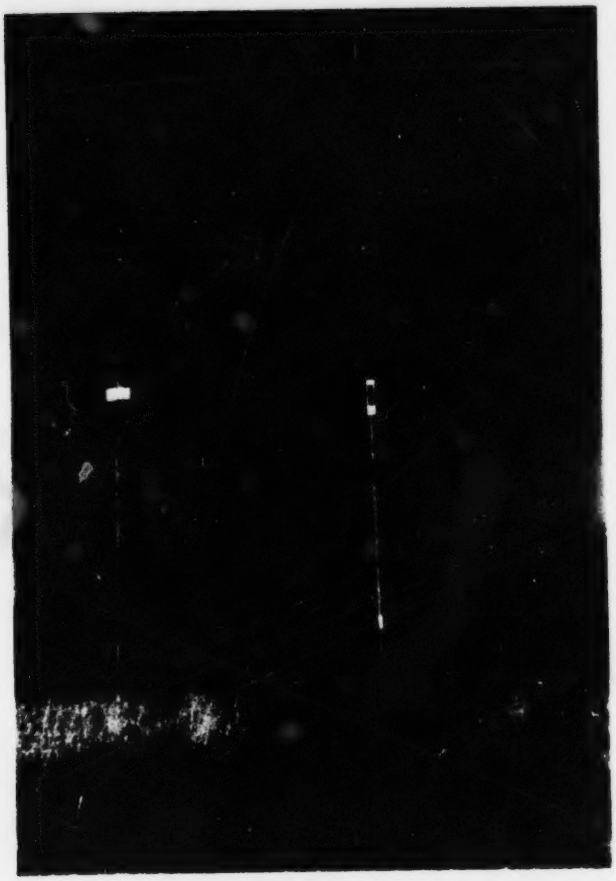
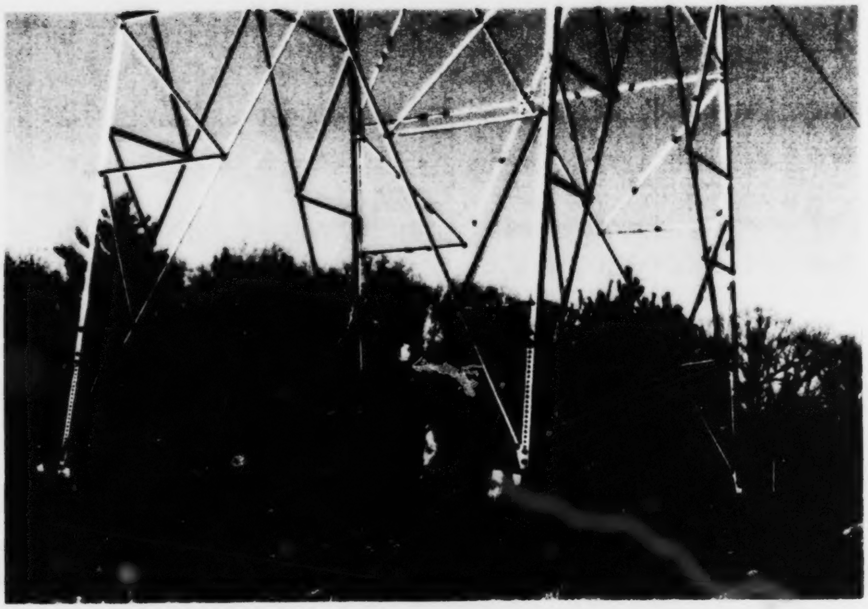


FIGURE 4

TOWER # 67 (NEAR SMITHS FALLS)

22 Tsang
Jana Disc



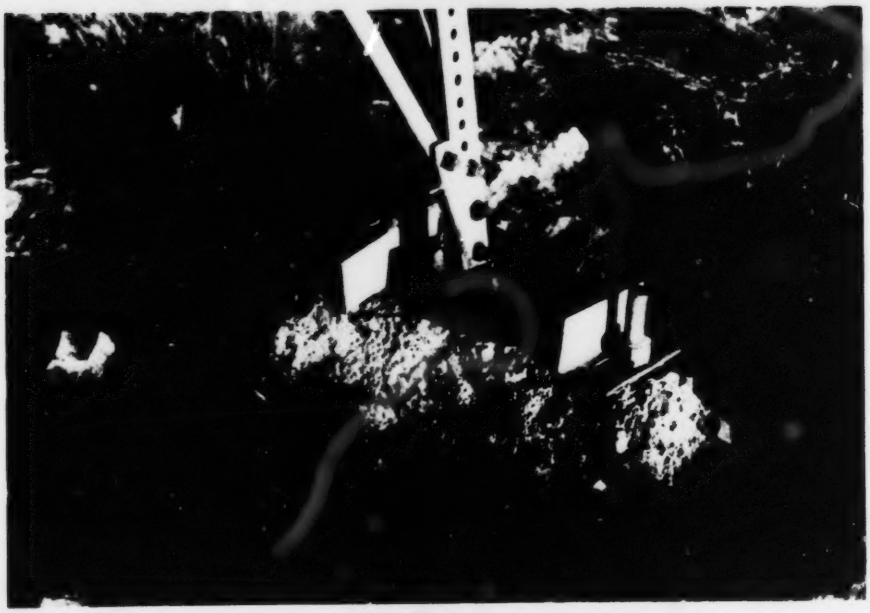


FIGURE 5

TOWER # 138 (NEAR JONES FALLS)

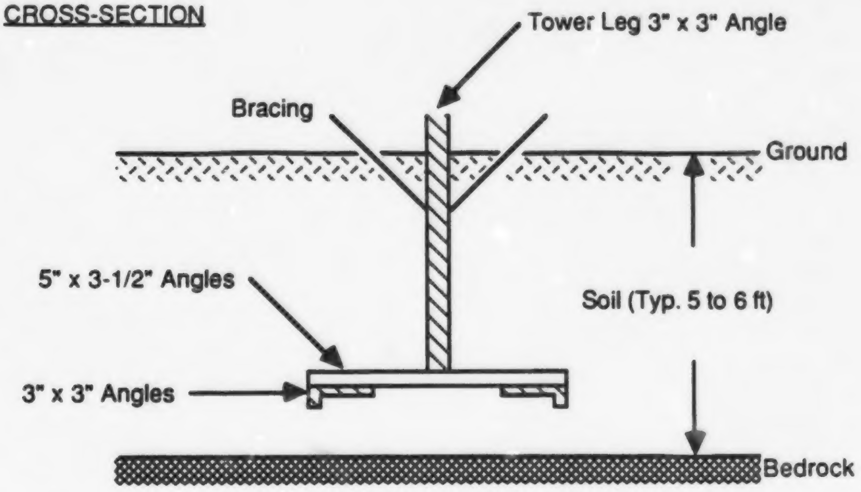
23 Tsang
Jana Disc

FIGURE 6

TOWER # 143 (NEAR JONES FALLS)

24 Tsang
Jana Disc

CROSS-SECTION


Tower Leg 3" x 3" Angle
Bracing
Ground
5" x 3-1/2" Angles
Soil (Typ. 5 to 6 ft)
3" x 3" Angles
Bedrock

PLAN

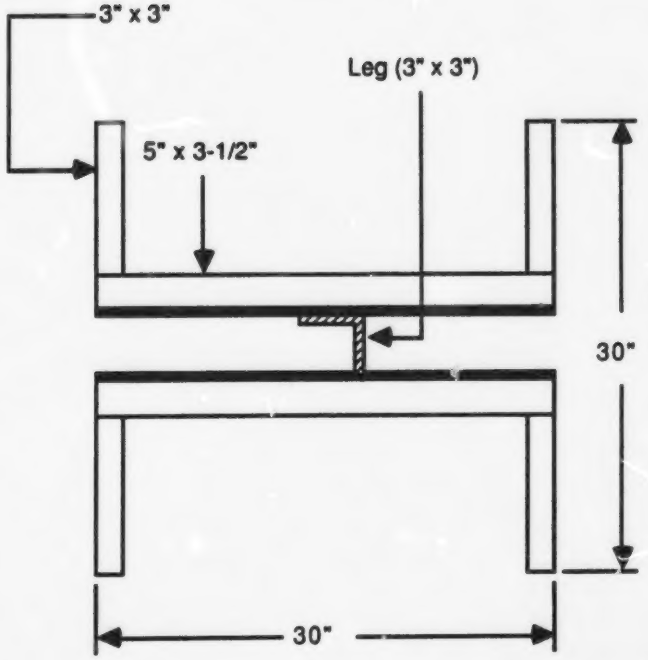

3" x 3"
Leg (3" x 3")
5" x 3-1/2"
30"
30"

FIGURE 7

GRILLAGE FOUNDATION DETAILS
(TOWER # 84 AND 143)

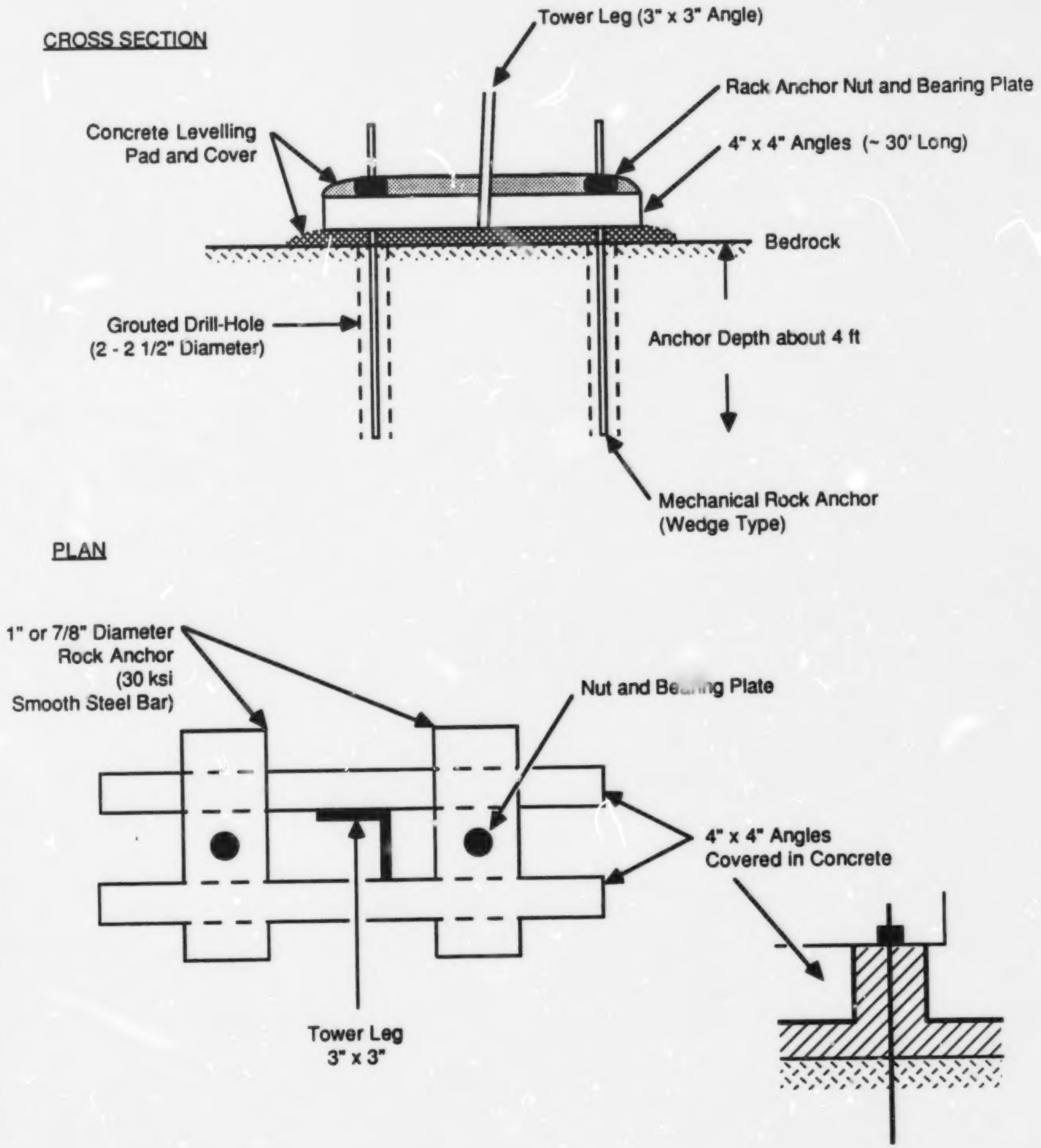

CROSS SECTION
Tower Leg (3" x 3" Angle)
Rack Anchor Nut and Bearing Plate
Concrete Levelling
Pad and Cover
4" x 4" Angles (~ 30' Long)
Bedrock
Grouted Drill-Hole
(2 - 2 1/2" Diameter)
Anchor Depth about 4 ft
Mechanical Rock Anchor
(Wedge Type)
PLAN
1" or 7/8" Diameter
Rock Anchor
(30 ksi
Smooth Steel Bar)
Nut and Bearing Plate
4" x 4" Angles
Covered in Concrete
Tower Leg
3" x 3"

FIGURE 8

ROCK ANCHOR FOUNDATION DETAILS
(TOWER # 145 AND 151)

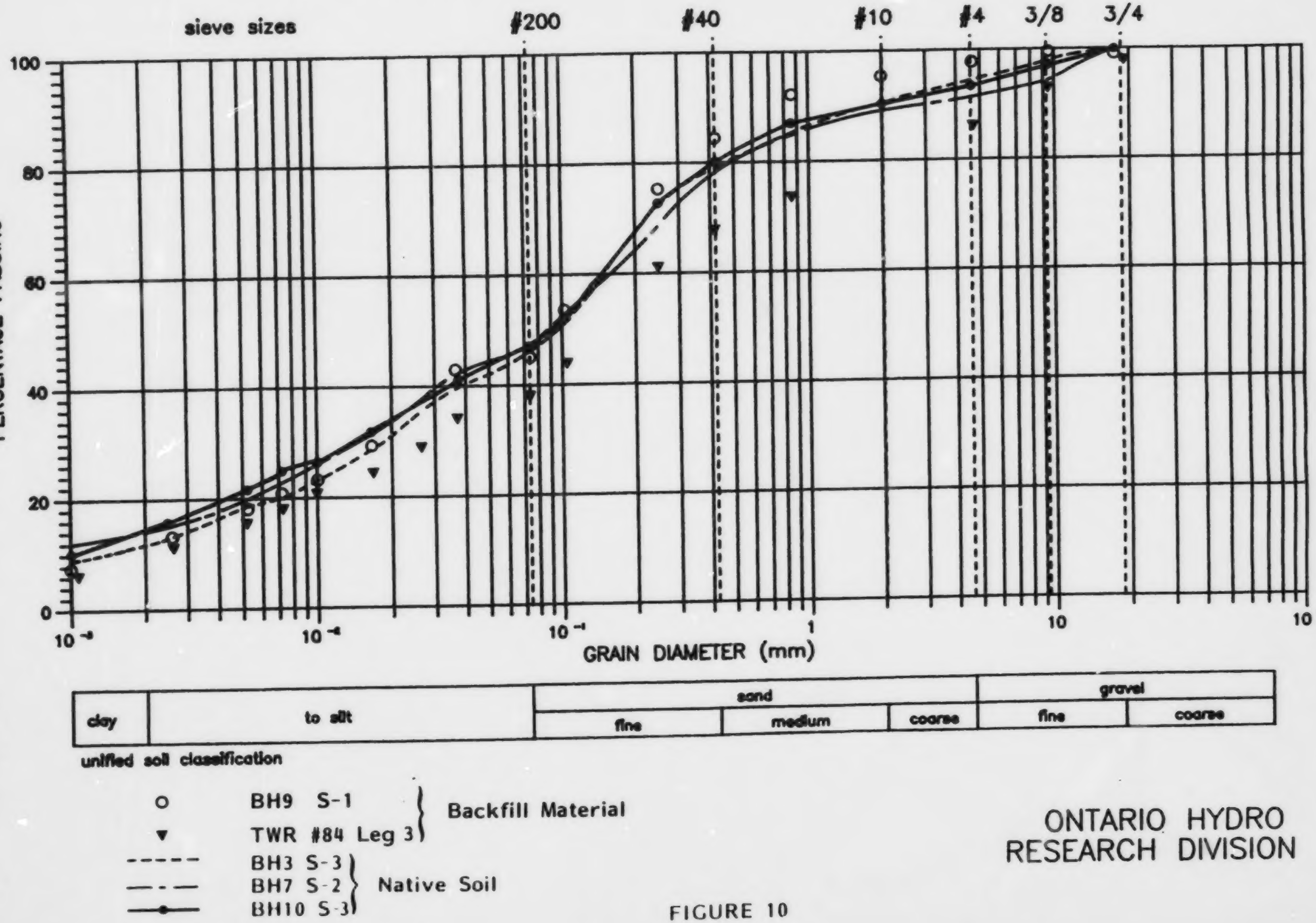
MAN STANDING
ON TOWER
FOOTING

FIGURE 9

GEOTECHNICAL INVESTIGATION OF NATIVE SOIL AND BACKFILL MATERIAL USING A DRILL RIG. STRAW AND PLASTIC TARP TO INSULATE TEST FOOTINGS FROM FROST

DILATOMETER (ABOVE) IN ADDITION TO STANDARD PENETRATION TESTS, DYNAMIC CONE AND SHELBY TUBE SAMPLES WERE PERFORMED AS PART OF THE FIELD INVESTIGATION

MECHANICAL ANALYSIS – TL Refurbishment Study Twr # 84 & 143



ONTARIO HYDRO
RESEARCH DIVISION

FIGURE 10

MECHANICAL ANALYSIS – TL Refurbishment Study Twr # 84 & 143

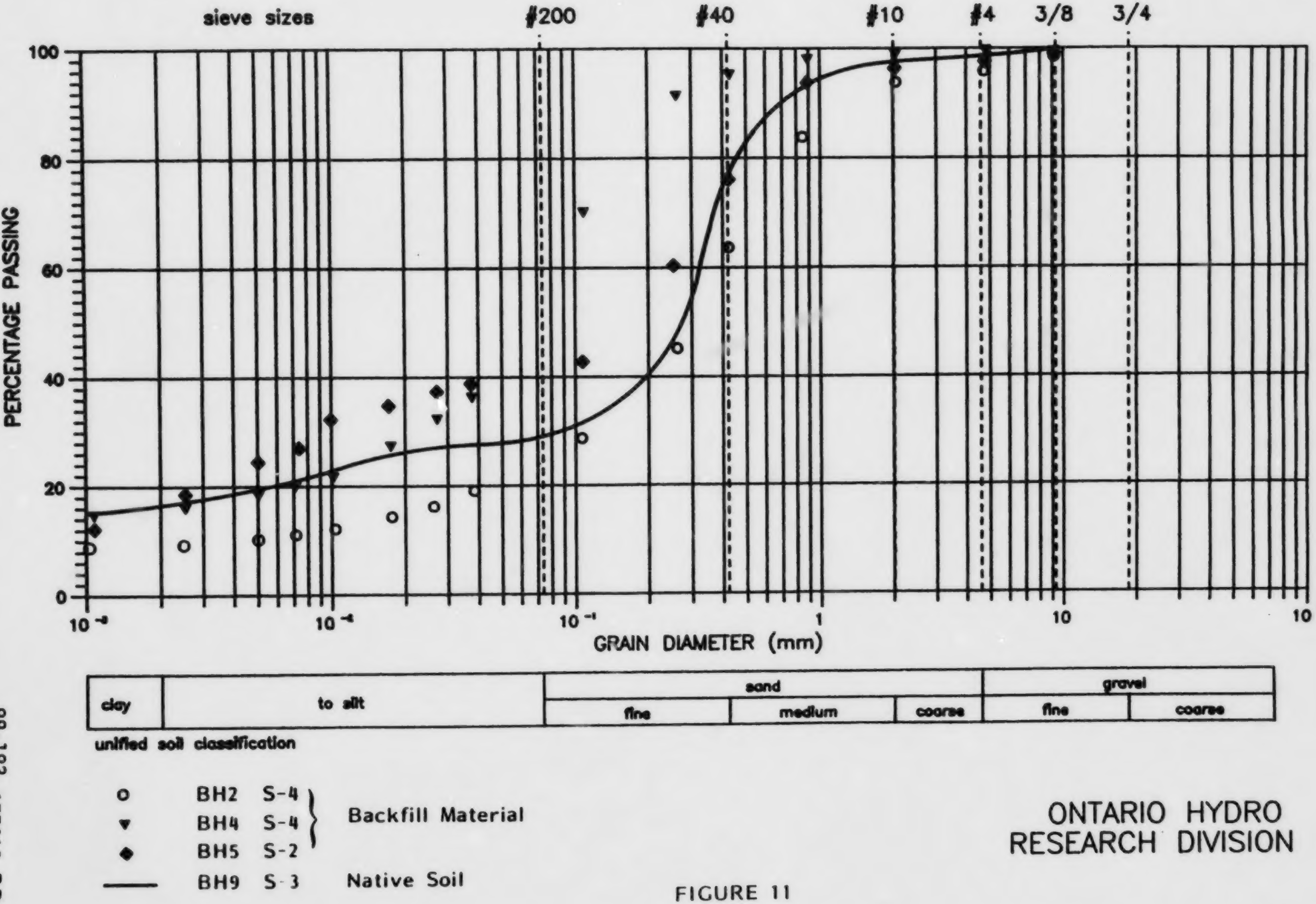
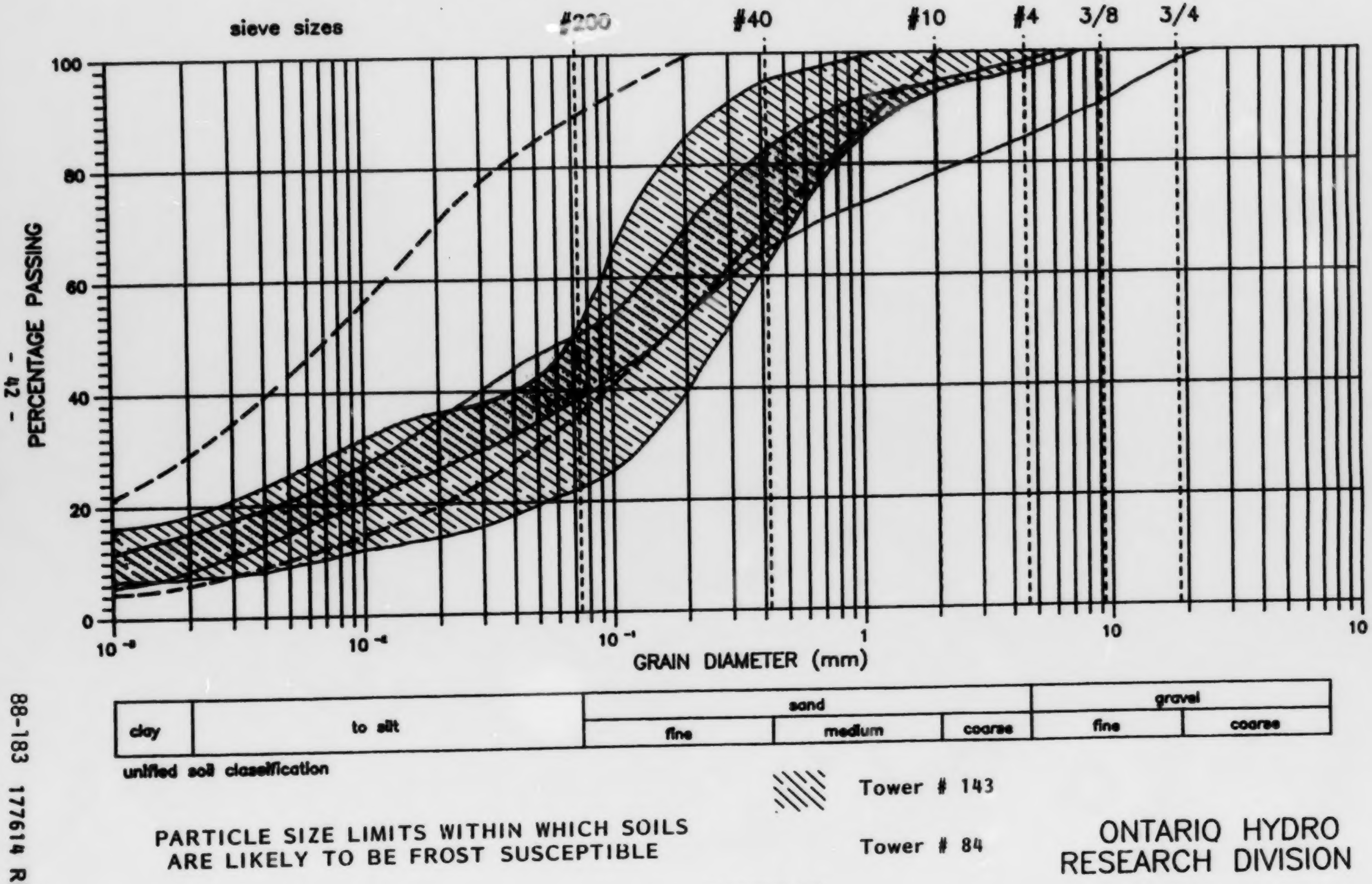


FIGURE 11

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS – TL Refurbishment Study Twr # 84 & 143



PARTICLE SIZE LIMITS WITHIN WHICH SOILS
ARE LIKELY TO BE FROST SUSCEPTIBLE

ONTARIO HYDRO
RESEARCH DIVISION

FIGURE 12

FIGURE 13

TYPICAL UPLIFT TEST SET-UP FOR EARTH GRILLAGES

PROPANE HEATERS AND MAKE-SHIFT SHELTERS WERE USED
TO DEFROST THE GROUND PRIOR TO FIELD LOAD TESTING

26 Tsang
Jana Disc

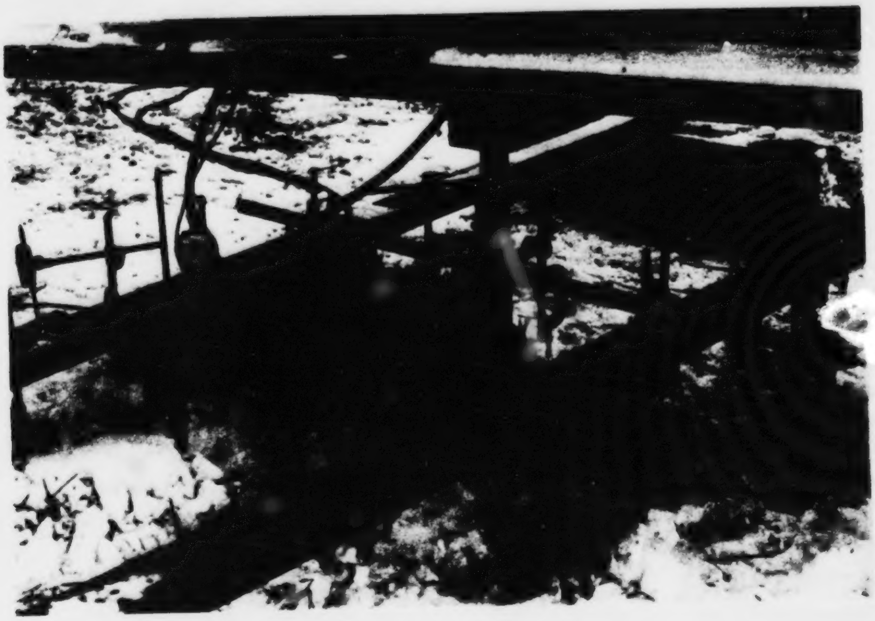


FIGURE 14

TELL-TALE INSTRUMENTATION AT TOWER # 143
FOR AN UPLIFT TEST

27 Tsang
Jana Disc

FIGURE 15

TYPICAL LATERAL SHEAR LOAD TEST ON GRILLAGE FOOTING. YELLOW HYDRAULIC RAM APPLIES THE LOAD TO THE GRILLAGE/ LEG MEMBER. A BULLDOZER WAS USED AS A REACTION FOR THE HYDRAULIC RAM

28 Tsang
Jana Disc

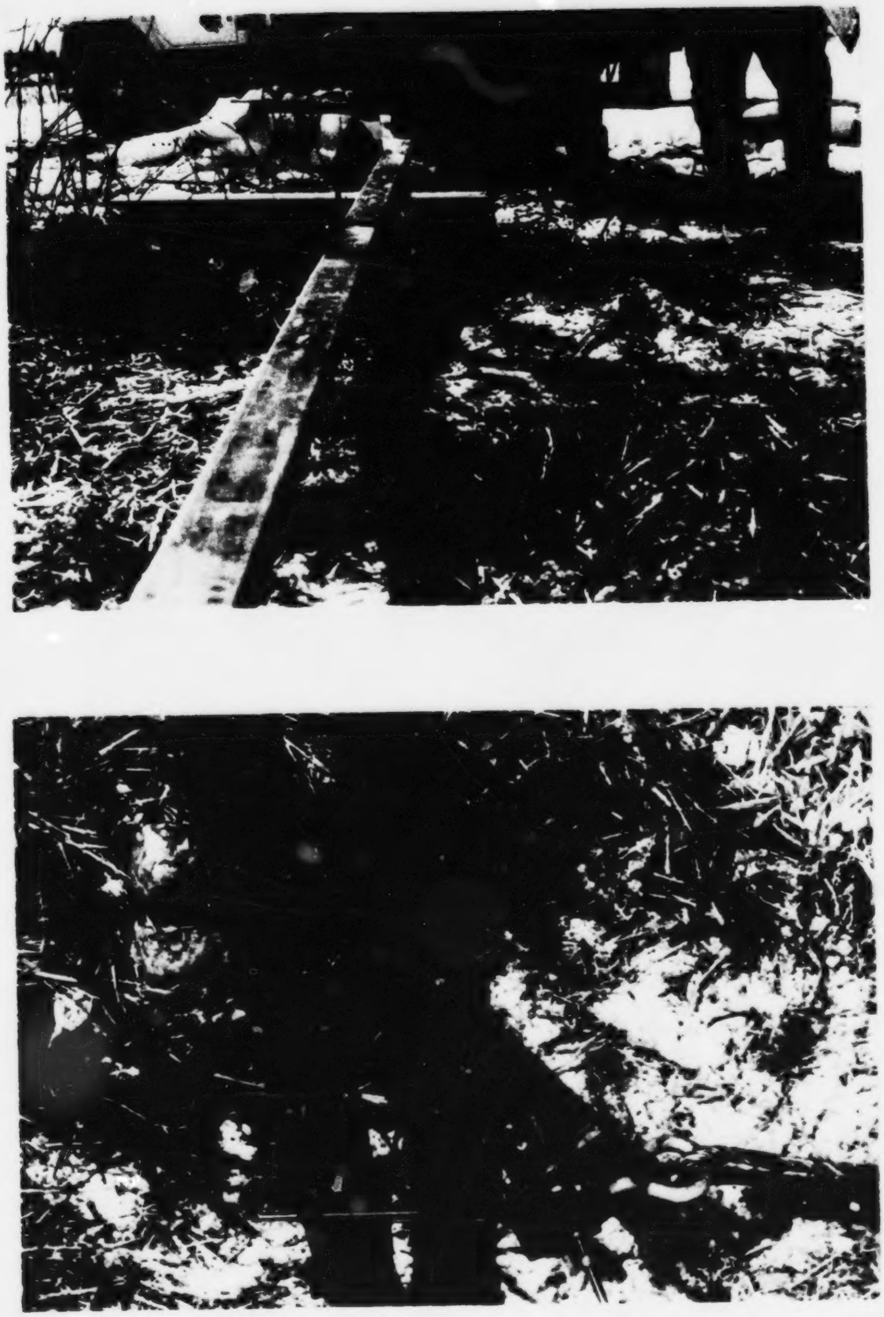
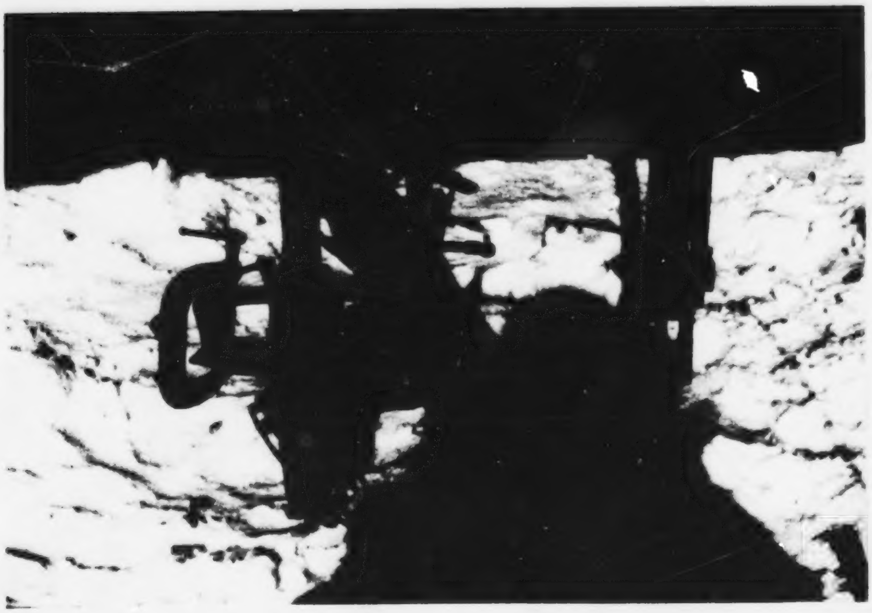


FIGURE 16

APPLIED LOADS AND DISPLACEMENTS OF THE GRILLAGE/LEG MEMBER AT GROUNDLINE WAS MONITORED DURING LATERAL SHEAR TEST

FIGURE 17

TYPICAL UPLIFT TEST SET-UP FOR ROCK ANCHORS



SPECIAL ADAPTER COUPLINGS TO ATTACHED PULL-RODS
TO EACH ROCK ANCHOR

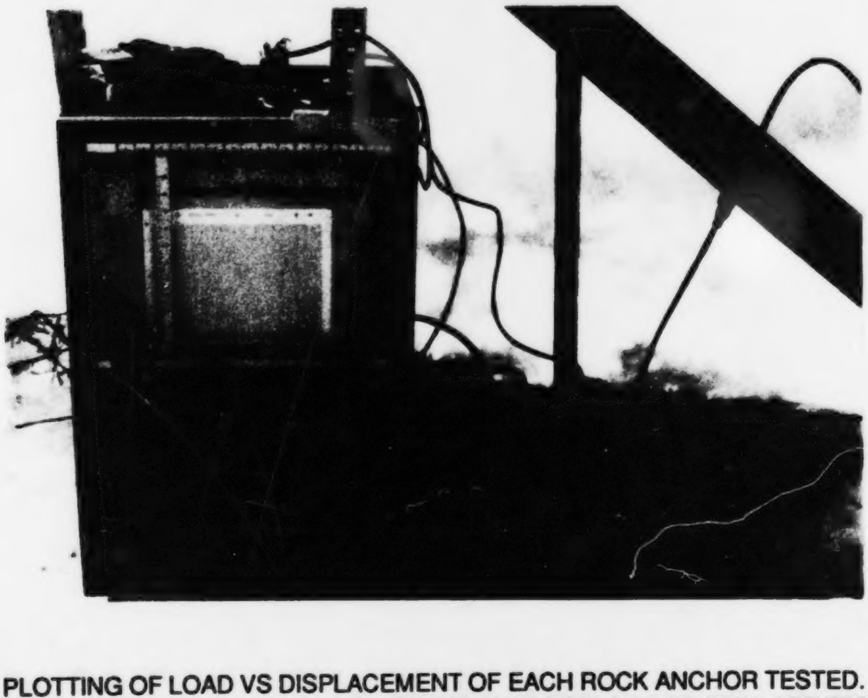
FIGURE 18

INSTALLATION OF TELL-TALE RODS USING PNEUMATIC PERCUSSION DRILL WITH 1-INCH DIAMETER BIT. SIX TELL-TALE RODS WERE INSTALLED AT VARIOUS DEPTHS IN THE ROCK

31 Tsang
Jana Disc

FIGURE 19

TYPICAL TELL-TALES TO MONITOR ROCK MOVEMENTS DURING ANCHOR PULL-OUT TEST



PLOTTING OF LOAD VS DISPLACEMENT OF EACH ROCK ANCHOR TESTED. INSTRUMENTATION AND DATA COLLECTION WAS SIMILAR FOR GRILLAGE TESTS

32 Tsang
Jana Disc

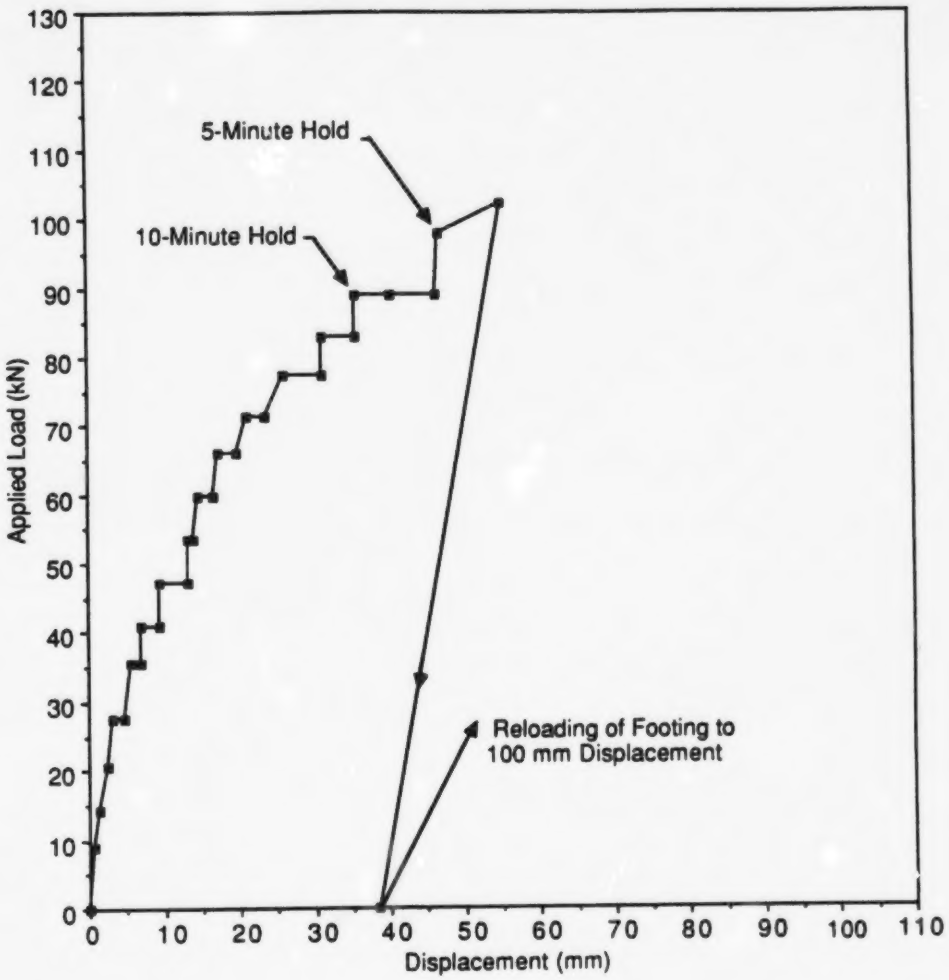


FIGURE 20

UPLIFT TEST AT TOWER # 84 LEG 4

TSANG 20
JA 6 DISK

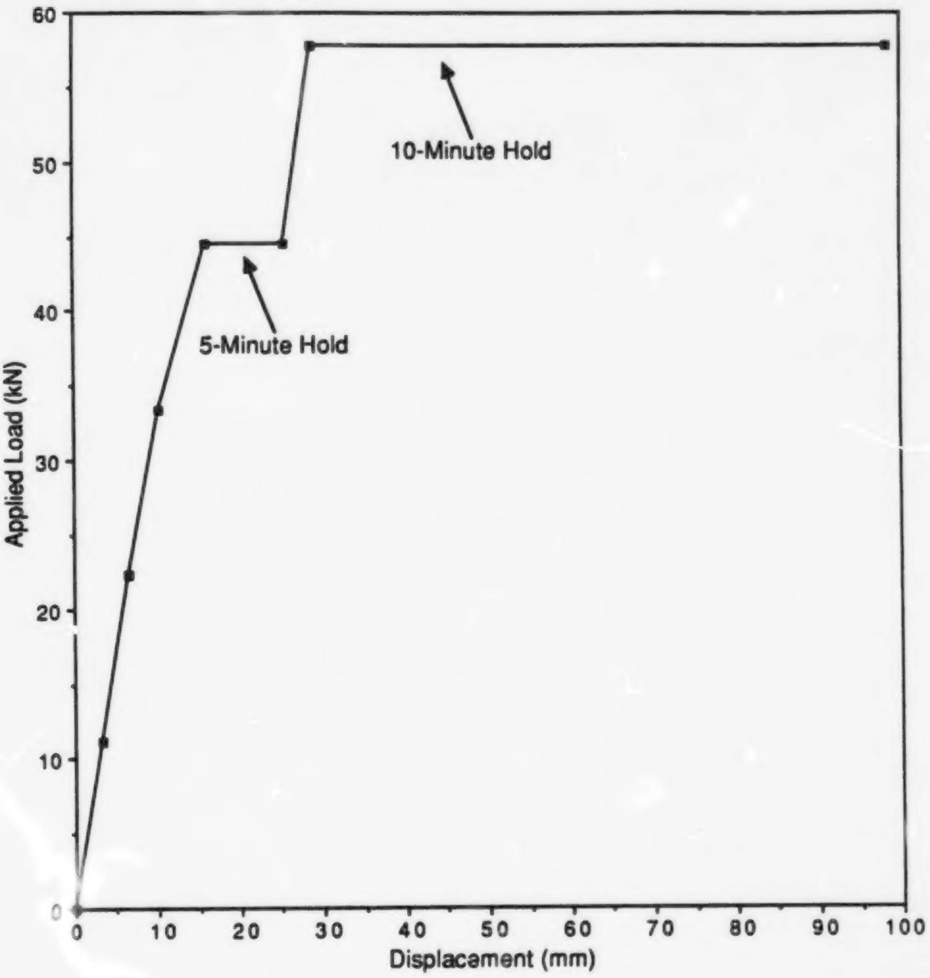


FIGURE 21

UPLIFT TEST AT TOWER 143 LEG 4

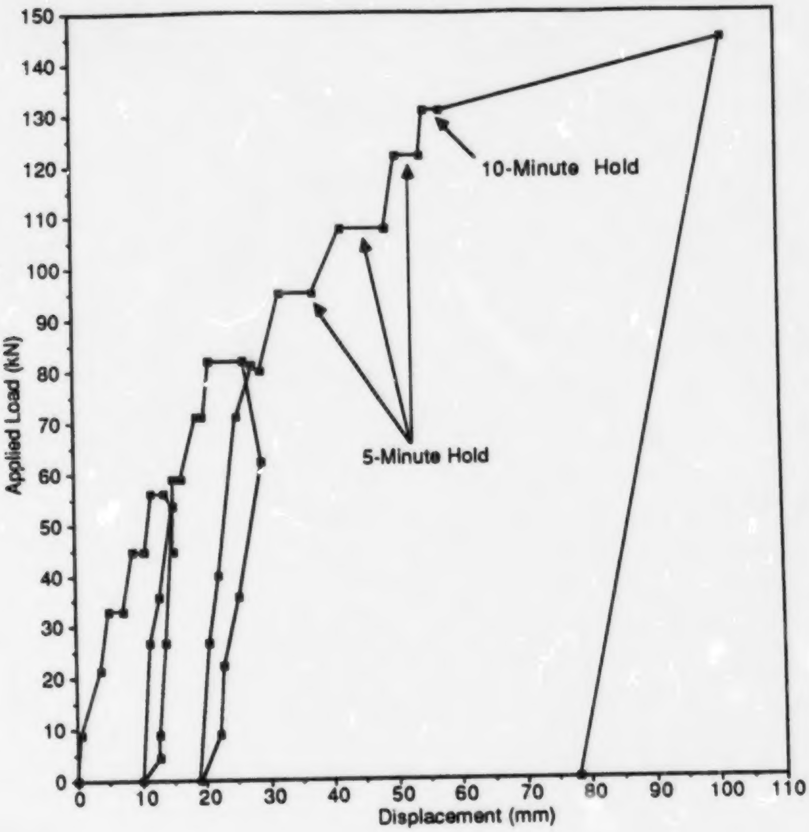


FIGURE 22

UPLIFT TEST AT TOWER # 84 LEG 2

TSANG 22
JA 6 DISK

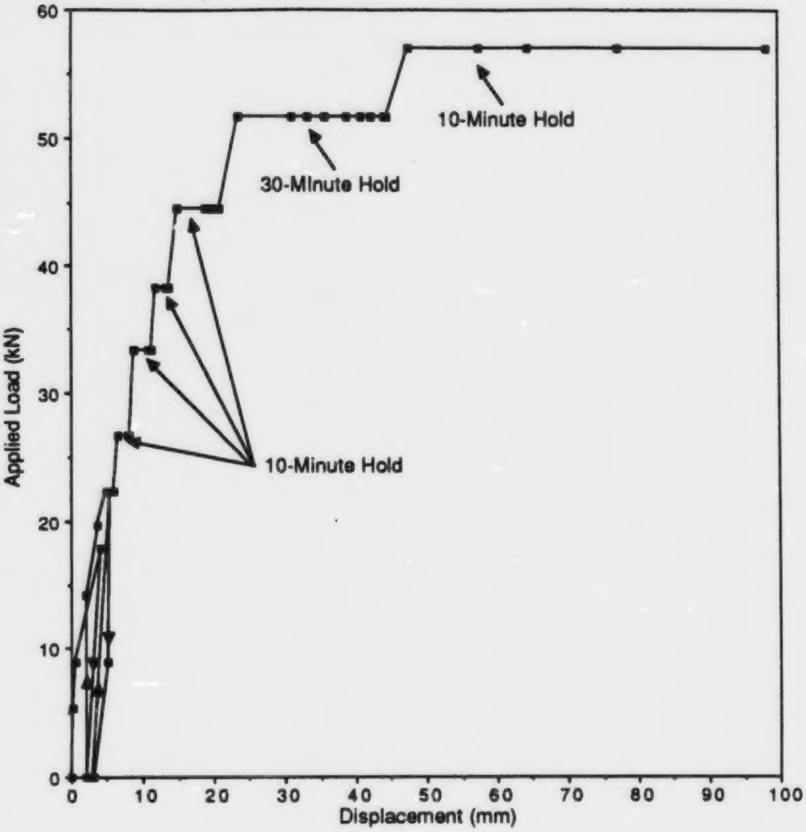
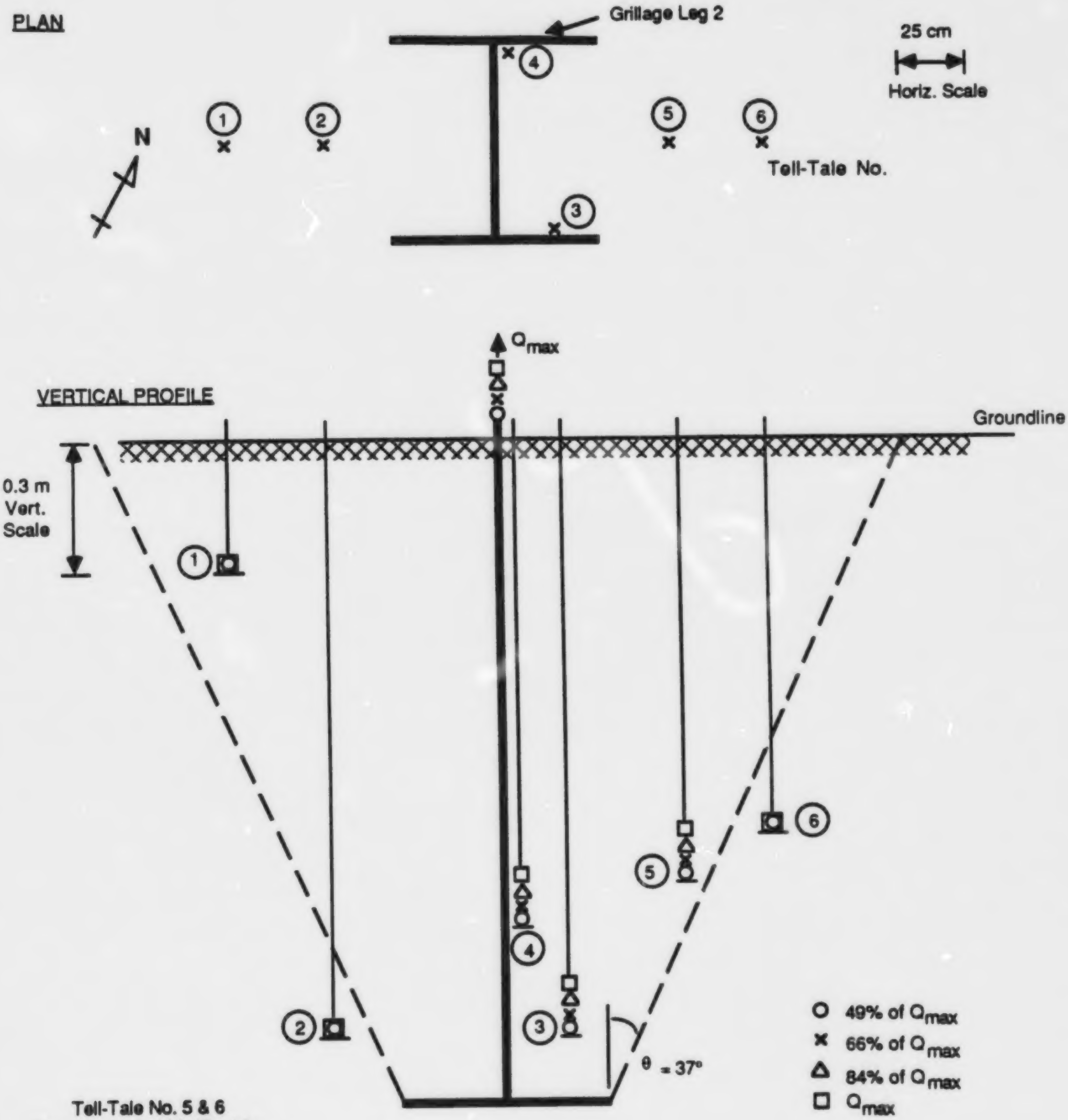


FIGURE 23

UPLIFT TEST AT TOWER # 143 LEG 2


PLAN
Grillage Leg 2
25 cm
Horiz. Scale
N
① ② ③ ④ ⑤ ⑥
Tell-Tale No.
VERTICAL PROFILE
Q_{max}
Groundline
0.3 m
Vert.
Scale
θ = 37°
○ 49% of Q_{max}
× 66% of Q_{max}
△ 84% of Q_{max}
□ Q_{max}

Tell-Tale No. 5 & 6
Resting on Cobble/Boulder
at Depth

FIGURE 24

TELL-TALE MOVEMENTS AT TOWER #84
LEG 2 FROM UPLIFT LOAD TEST

177432-RD
CAZ-3

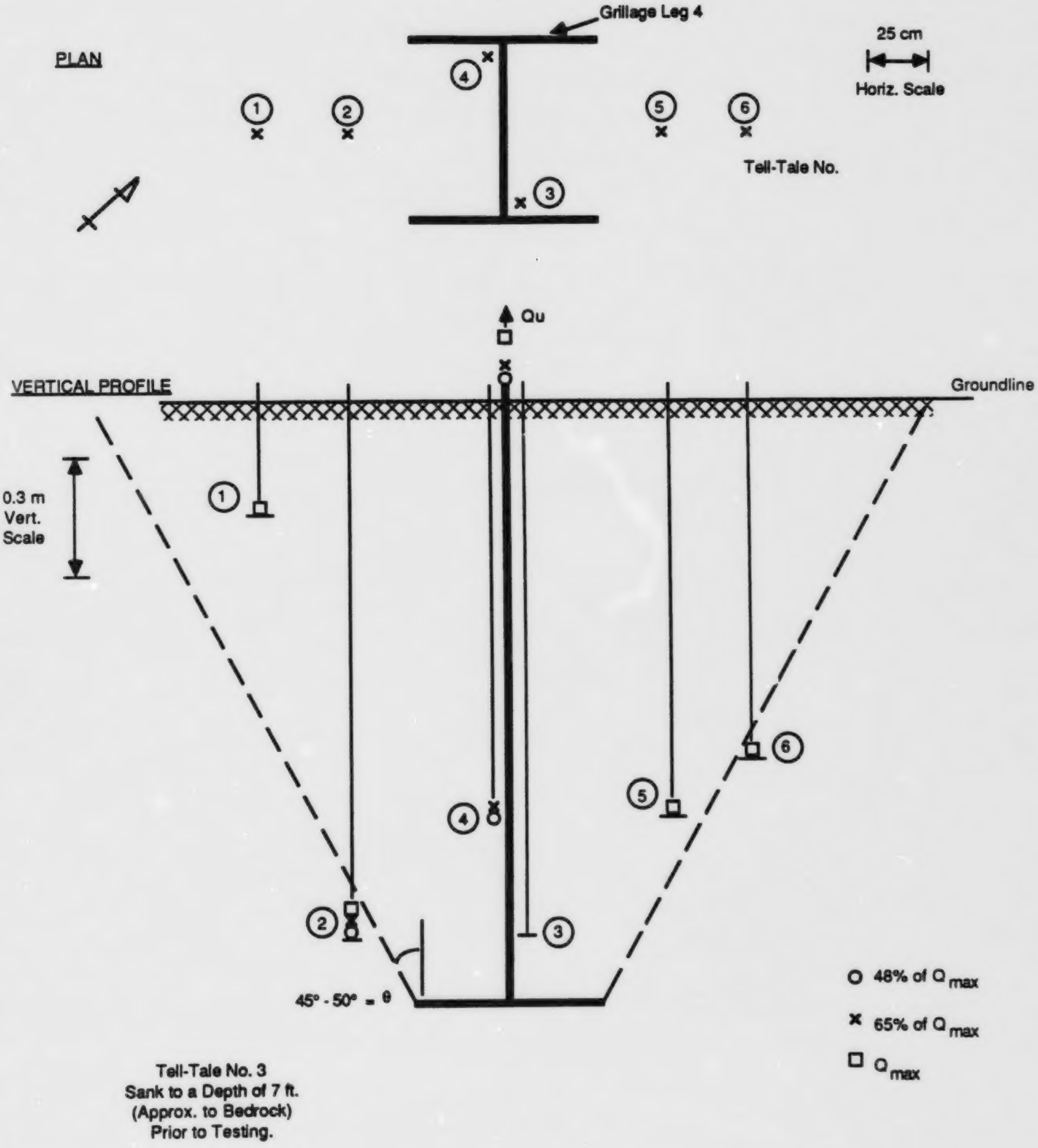

PLAN
Grillage Leg 4
25 cm
Horiz. Scale
① ② ④ ③ ⑤ ⑥
Tell-Tale No.
Qu
VERTICAL PROFILE
Groundline
0.3 m
Vert.
Scale
45° - 50° = θ
○ 48% of Q max
× 65% of Q max
☐ Q max
Tell-Tale No. 3
Sank to a Depth of 7 ft.
(Approx. to Bedrock)
Prior to Testing.

FIGURE 25

TELL-TALE MOVEMENTS AT TOWER #84
LEG 4 FROM UPLIFT LOAD TEST

177431-RD
CAZ-3

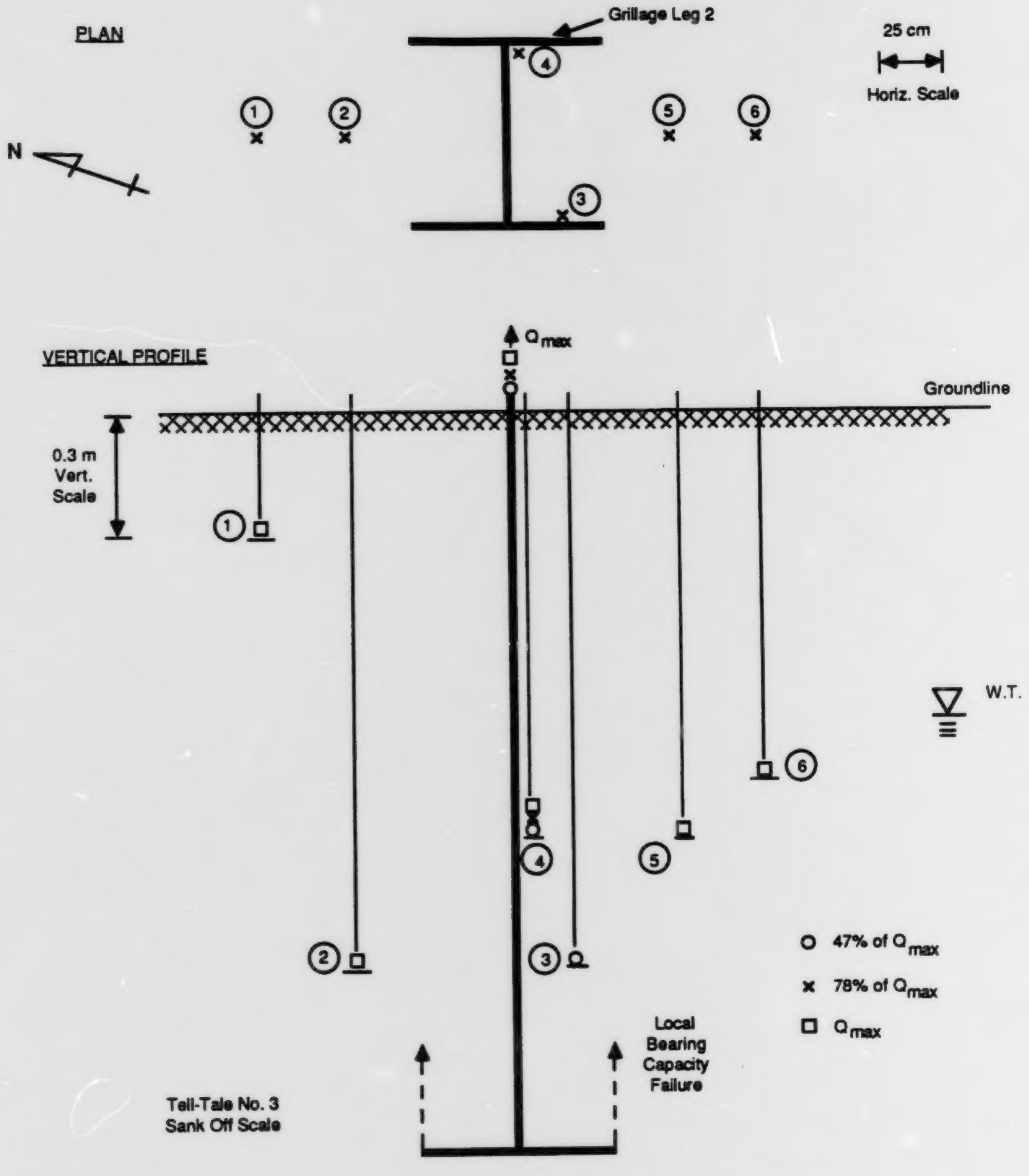

PLAN
Grillage Leg 2
25 cm
Horiz. Scale
N
①
②
③
④
⑤
⑥
VERTICAL PROFILE
Q max
Groundline
0.3 m
Vert.
Scale
W.T.
○ 47% of Q_{max}
× 78% of Q_{max}
□ Q_{max}
Local
Bearing
Capacity
Failure
Tell-Tale No. 3
Sank Off Scale

FIGURE 26

TELL-TALE MOVEMENTS AT TOWER #143
LEG 2 FROM UPLIFT LOAD TEST

177430-RD
CAZ-3

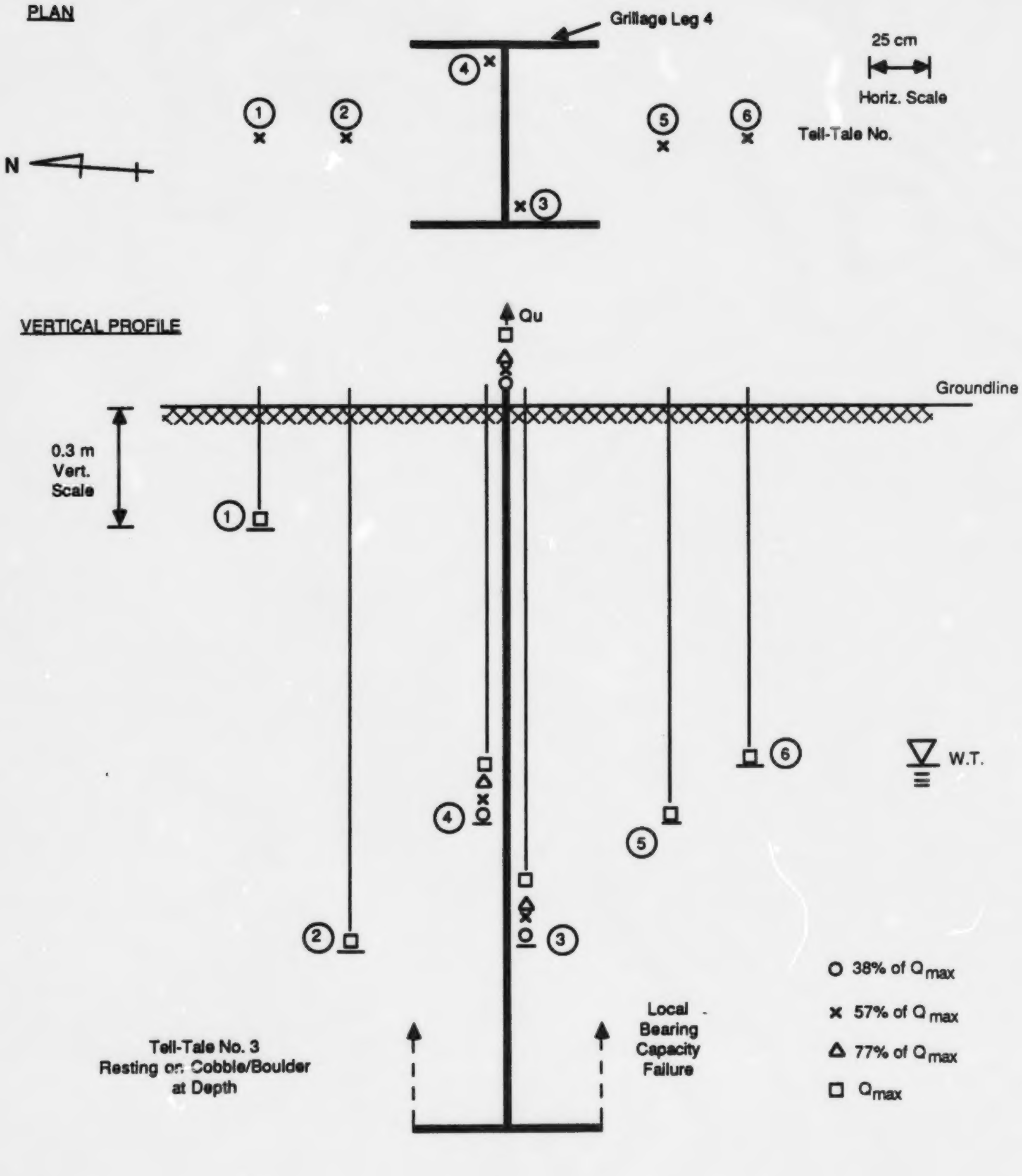

PLAN
Grillage Leg 4
25 cm
Horiz. Scale
N
① ② ③ ④ ⑤ ⑥
Tell-Tale No.
VERTICAL PROFILE
Qu
Groundline
0.3 m
Vert.
Scale
W.T.
Tell-Tale No. 3
Resting on Cobble/Boulder
at Depth
Local
Bearing
Capacity
Failure
○ 38% of Q_{max}
× 57% of Q_{max}
△ 77% of Q_{max}
☐ Q_{max}

FIGURE 27

TELL-TALE MOVEMENTS AT TOWER #143
LEG 4 FROM UPLIFT TEST

177429-RD
CAZ-3

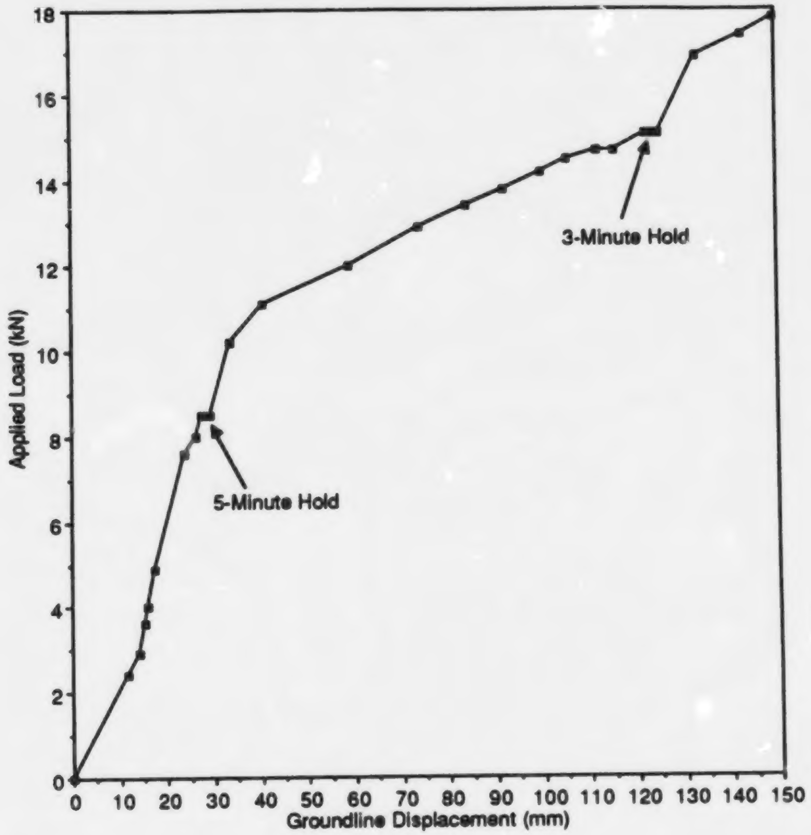


FIGURE 28

LATERAL SHEAR TEST AT TOWER # 84 LEG 1

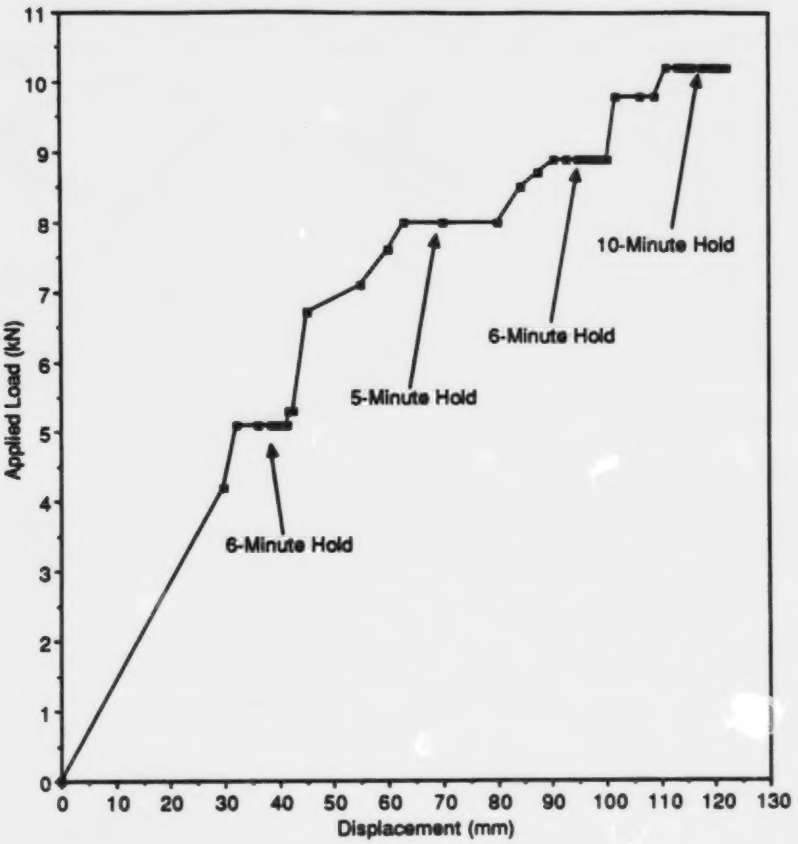
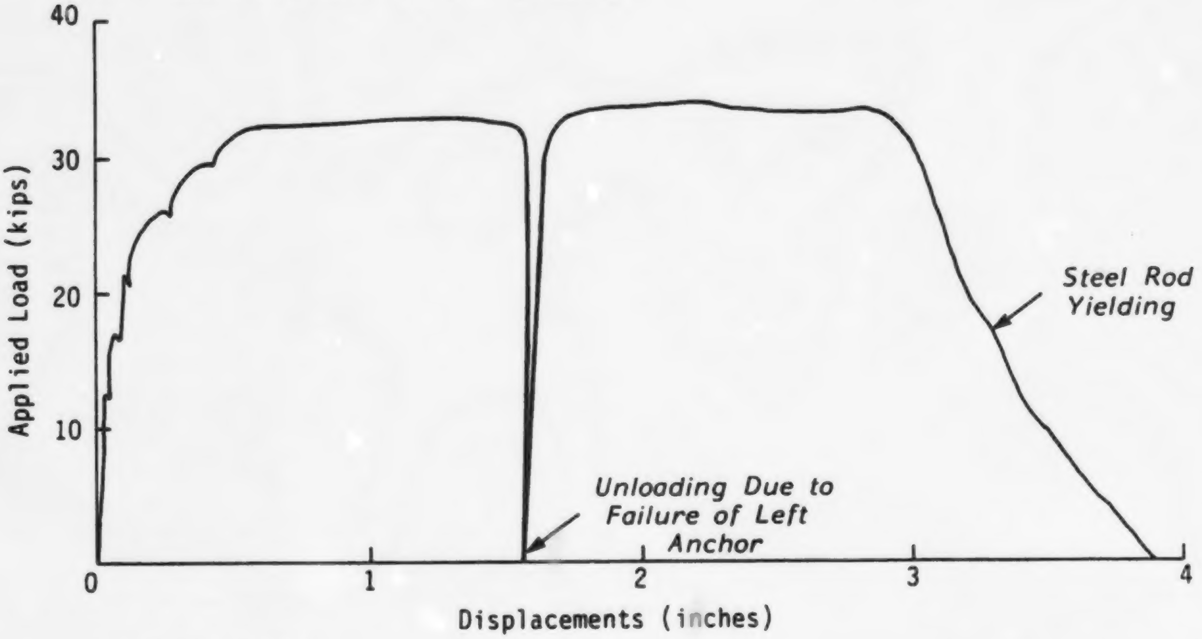


FIGURE 29

LATERAL SHEAR TEST AT TOWER # 143 LEG 3

Right Rock Anchor

(17" Centre-to-Centre Anchor Spacing)



1 kip = 4.45 kN
1 inch = 25.4 mm

Left Rock Anchor

(17" Centre-to-Centre Anchor Spacing)

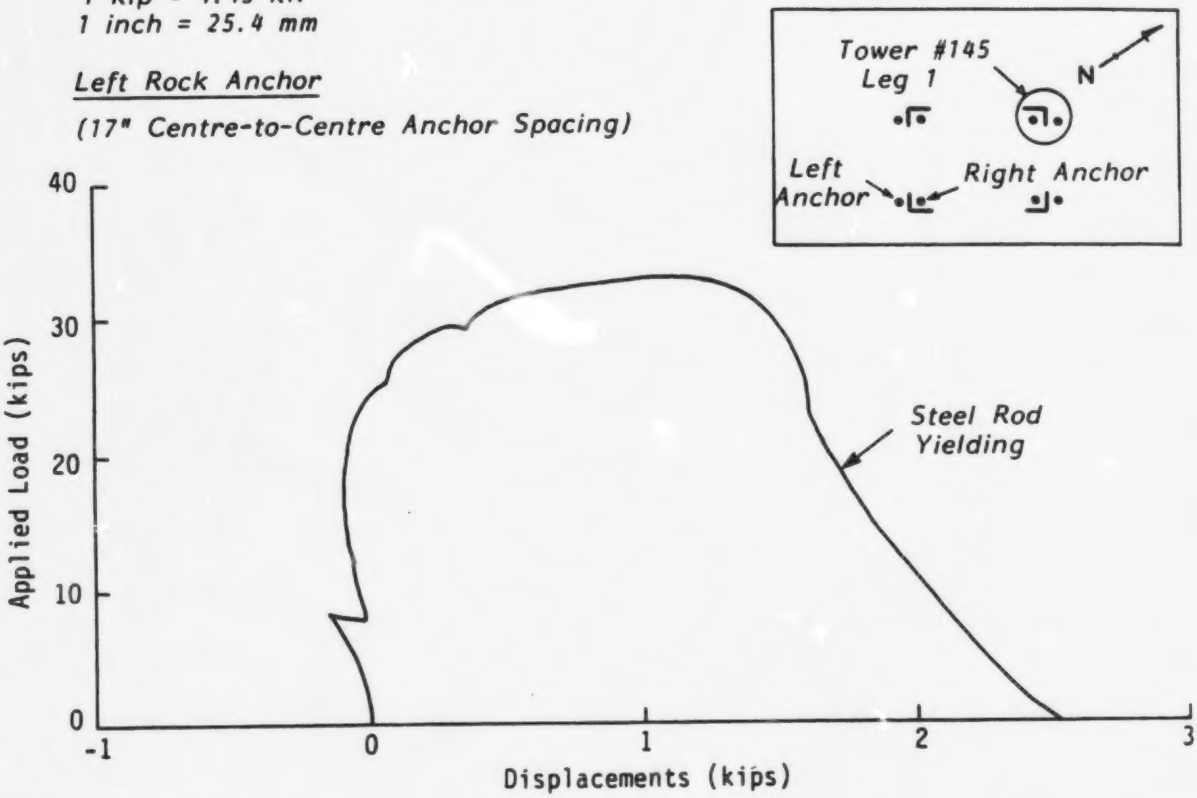
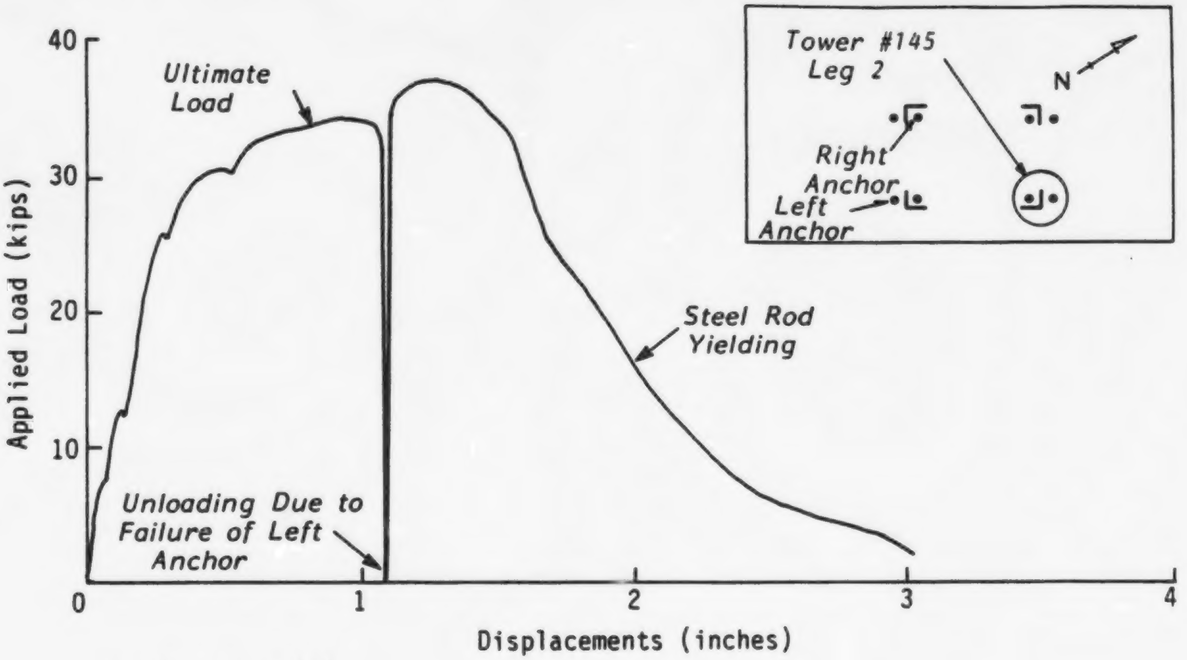


FIGURE 30

ROCK ANCHOR UPLIFT TEST AT TOWER #145 LEG 1

Right Rock Anchor



1 kip = 4.45 kN
1 inch = 25.4 mm

Left Rock Anchor

(19" Centre-to-Centre Anchor Spacing)

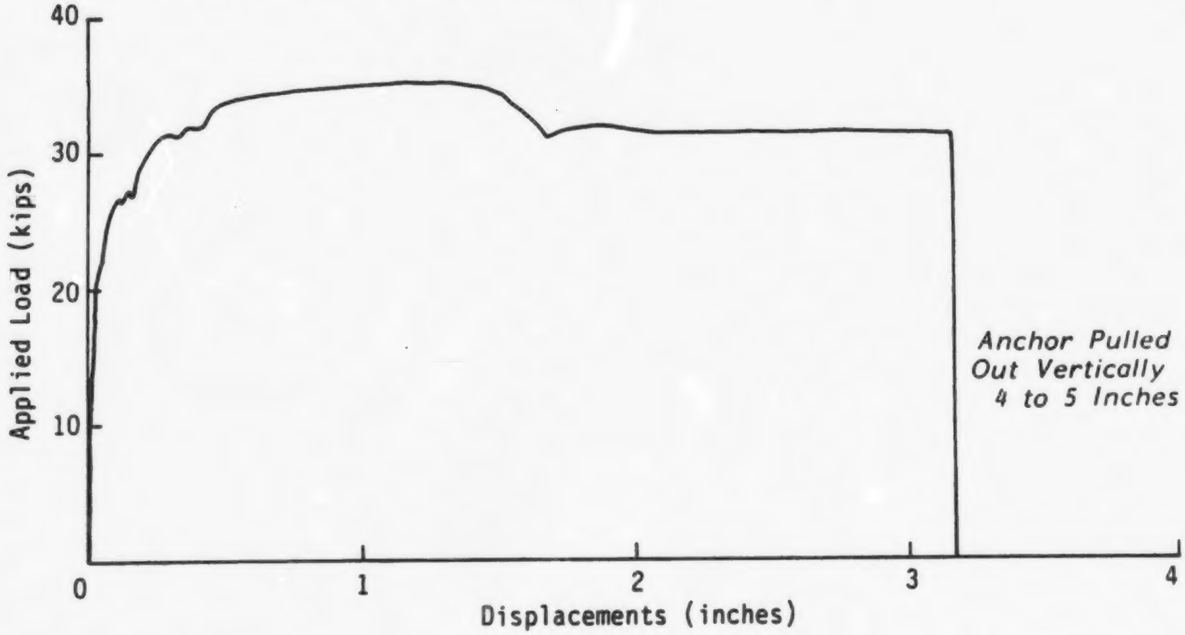


FIGURE 31

ROCK ANCHOR UPLIFT TEST AT
TOWER #145 LEG 2

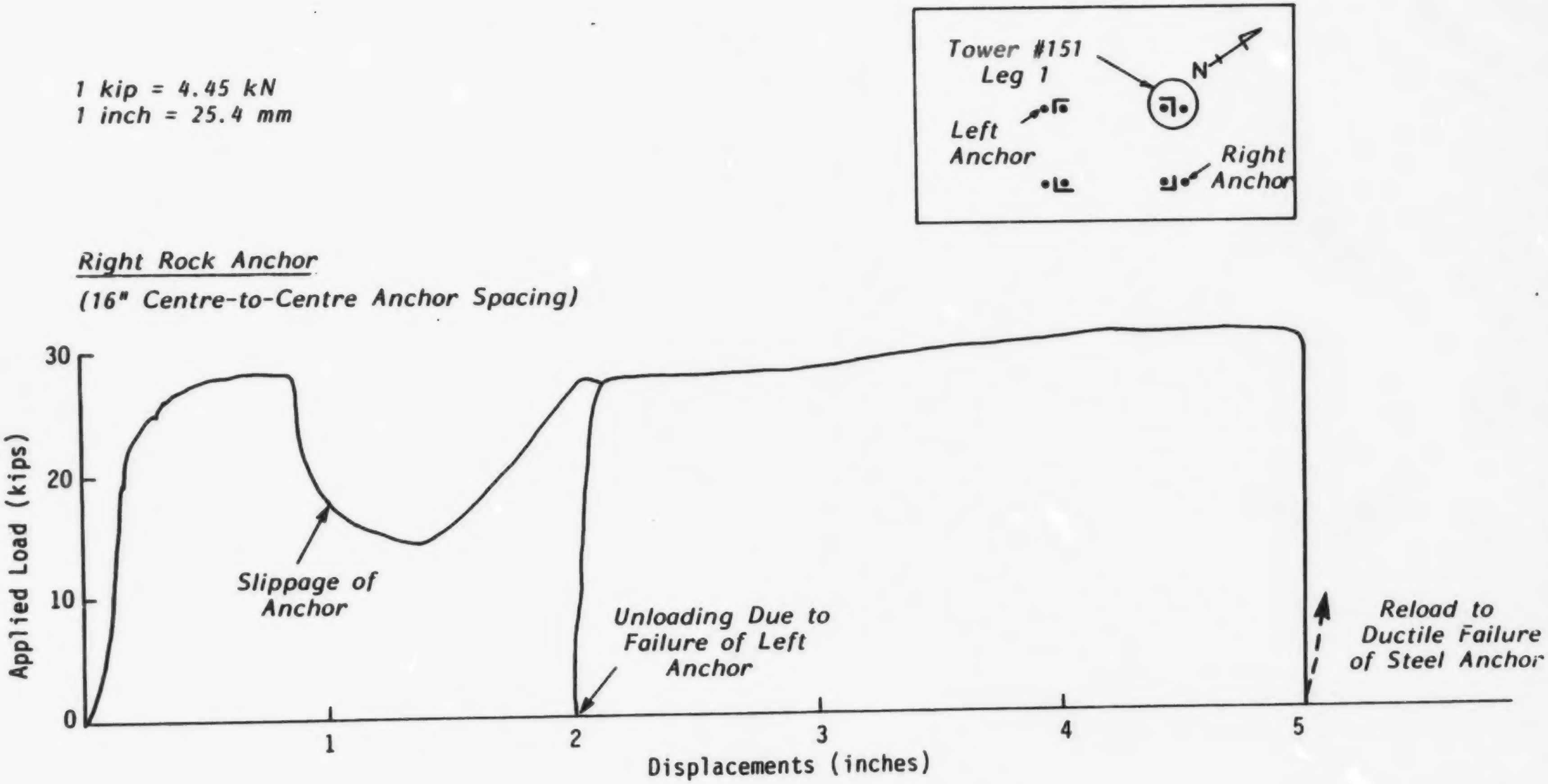


FIGURE 32

ROCK ANCHOR UPLIFT TEST AT
TOWER #151 LEG 1

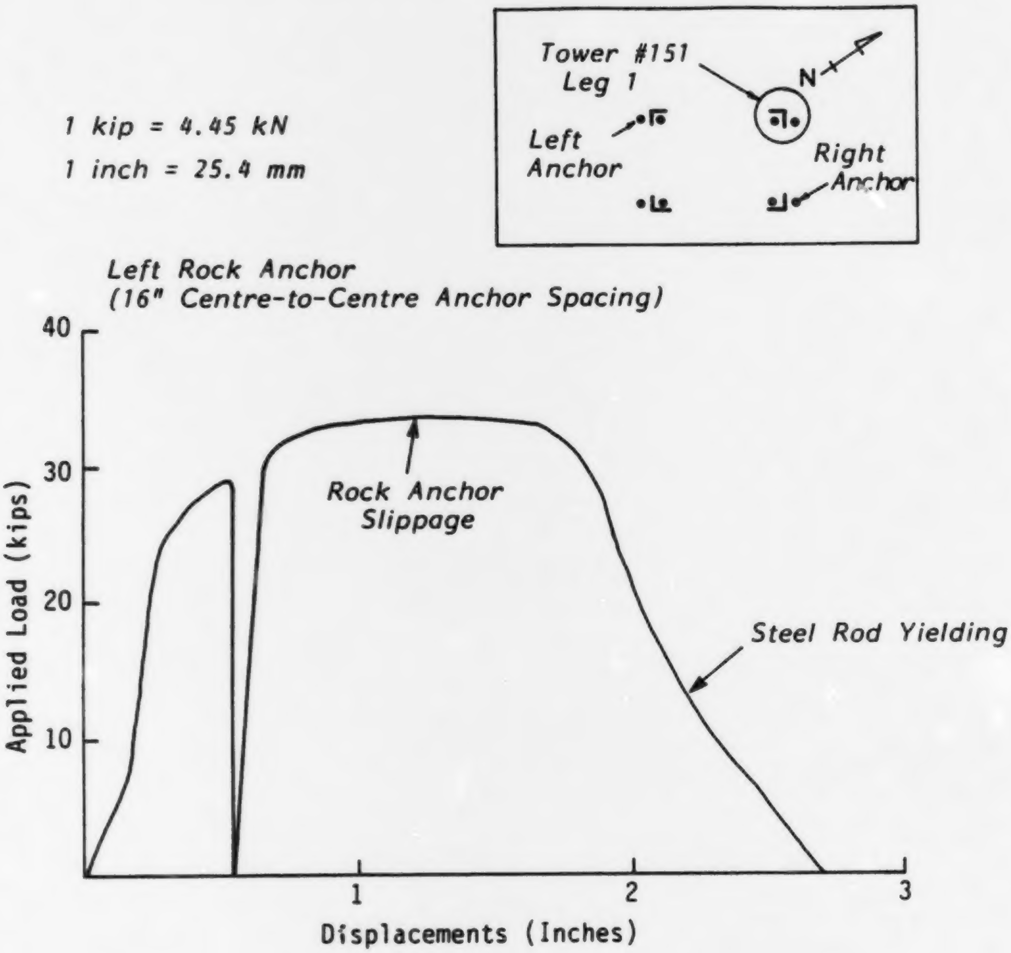
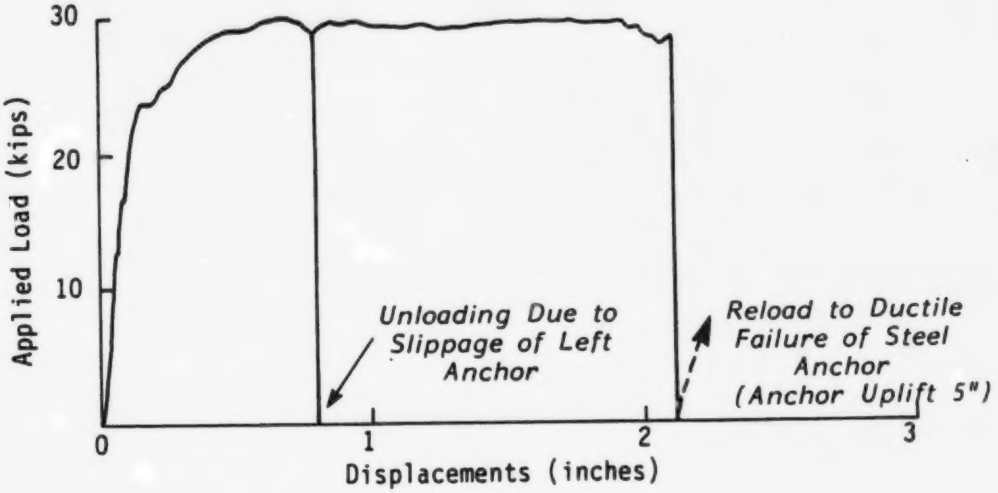


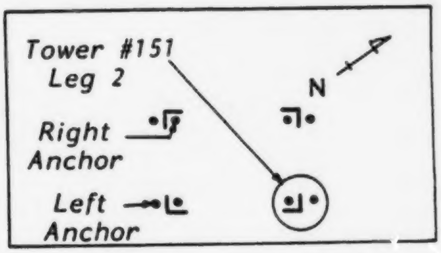
FIGURE 33

ROCK ANCHOR UPLIFT TEST AT
TOWER #151 LEG 1

Right Rock Anchor



1 kip = 4.45 kN
1 inch = 25.4 mm


Tower #151 Leg 2
N
Right Anchor
Left Anchor

Left Rock Anchor

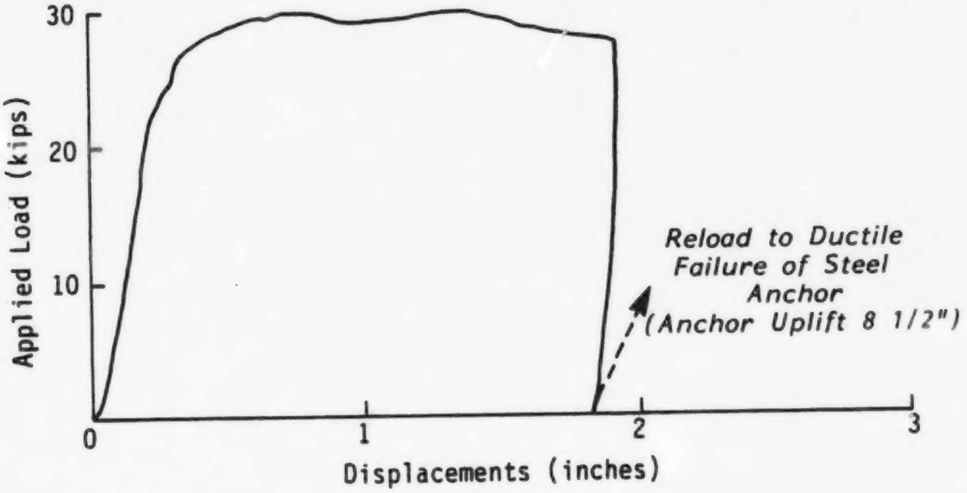
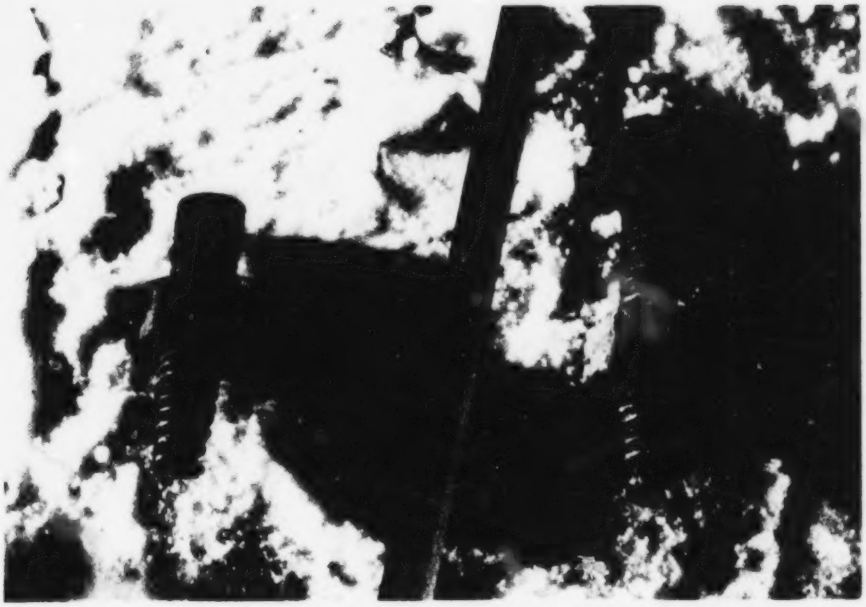


FIGURE 34

ROCK ANCHOR UPLIFT TEST AT TOWER #151 LEG 2



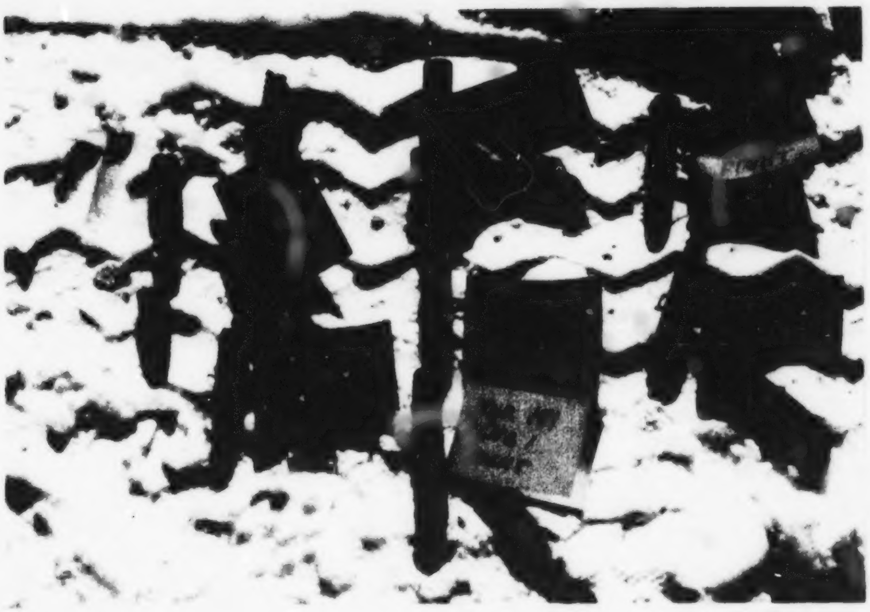


FIGURE 35

DUCTILE FAILURE OF THE STEEL ROCK ANCHOR BOLTS TESTED

1 Tsang
Jana Disc

APPENDIX A

FIELD INSPECTION OF TOWER FOUNDATIONS AT SELECTED SITES

FIGURE A1

SUPERFICIAL RUST MAINLY ON GRILLAGE "MAT" MEMBERS
AT A DEPTH OF 5 - 6 ft AT TOWER # 143

6 Tsang
Jana Disc

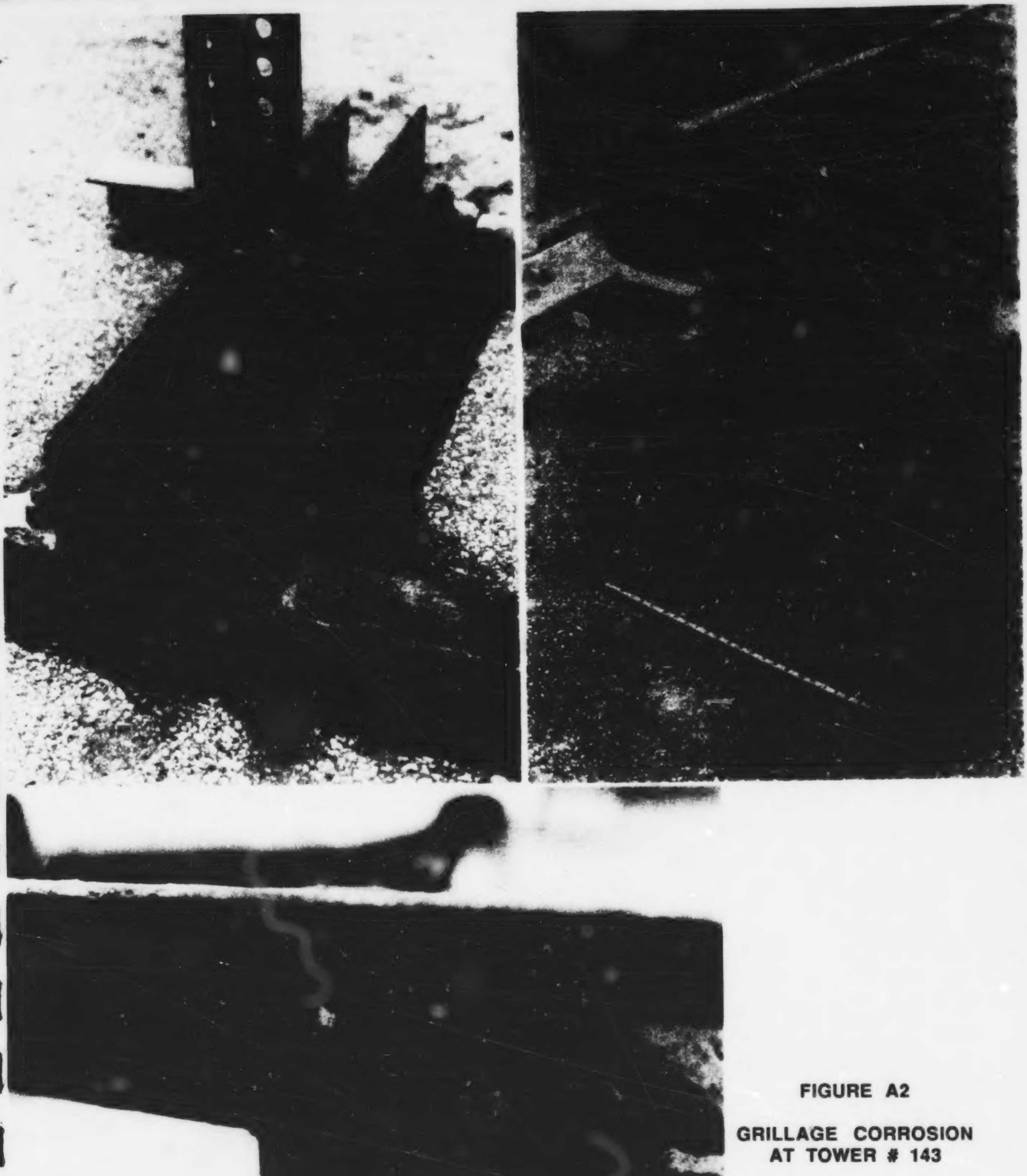


FIGURE A2

GRILLAGE CORROSION
AT TOWER # 143

7 Tsang
Jana Disc

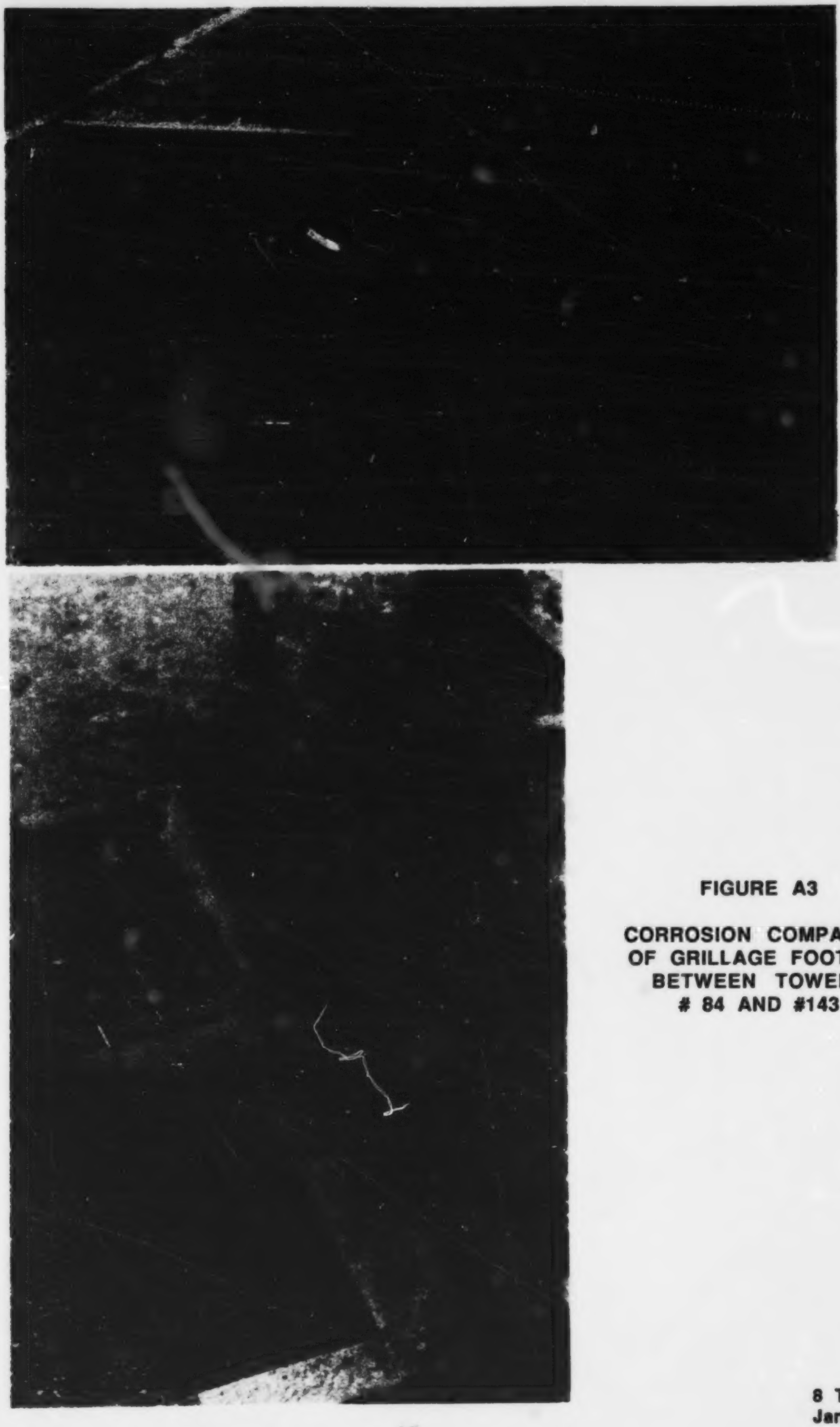


FIGURE A3

CORROSION COMPARISON OF GRILLAGE FOOTAGE BETWEEN TOWERS # 84 AND #143

8 Tsang
Jana Disc

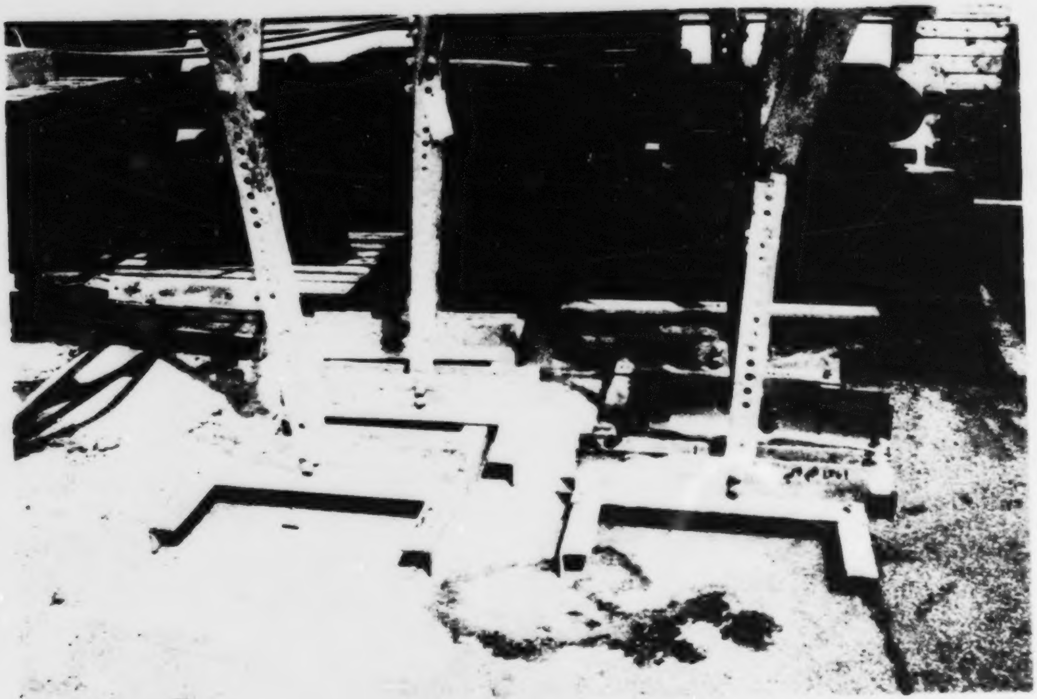
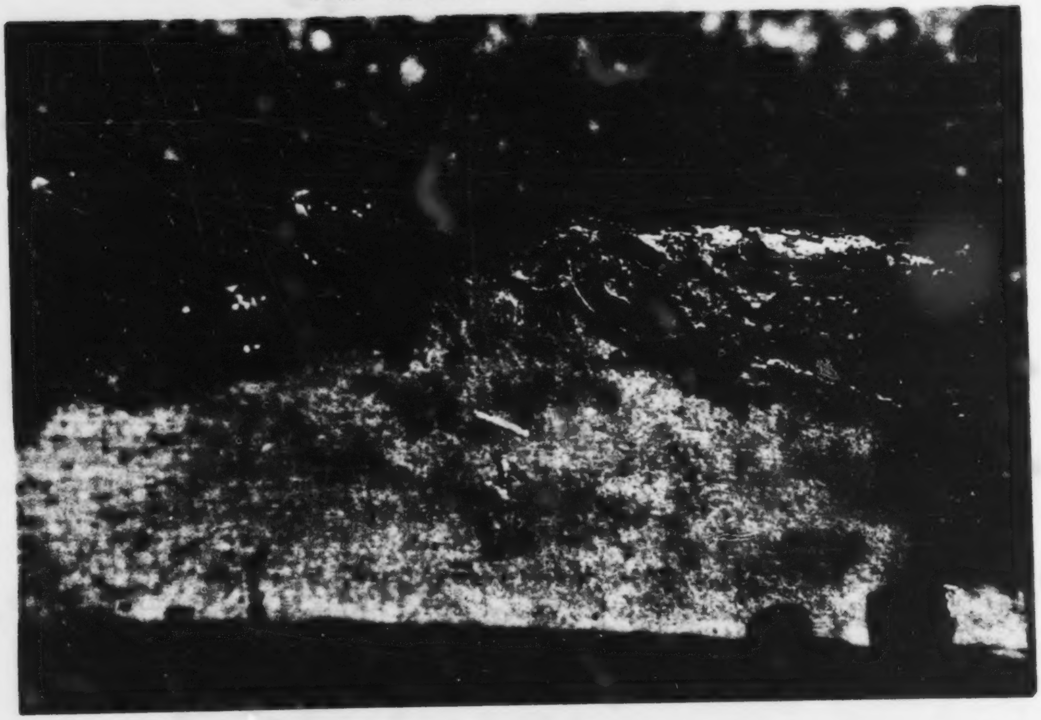


FIGURE A4

DIFFERENCE IN DEGREE OF CORROSION AS INDICATED BY THE TEST FOOTINGS EXCAVATED FROM TOWER # 84 (LEFT) AND TOWER # 143 (RIGHT)/8/



UPON REMOVAL OF THE CORROSION PRODUCT FROM TOWER # 143 LEG 2, PITTINGS 0.03" DEEP WERE EXPOSED/8/

9 Tsang
Jana Disc

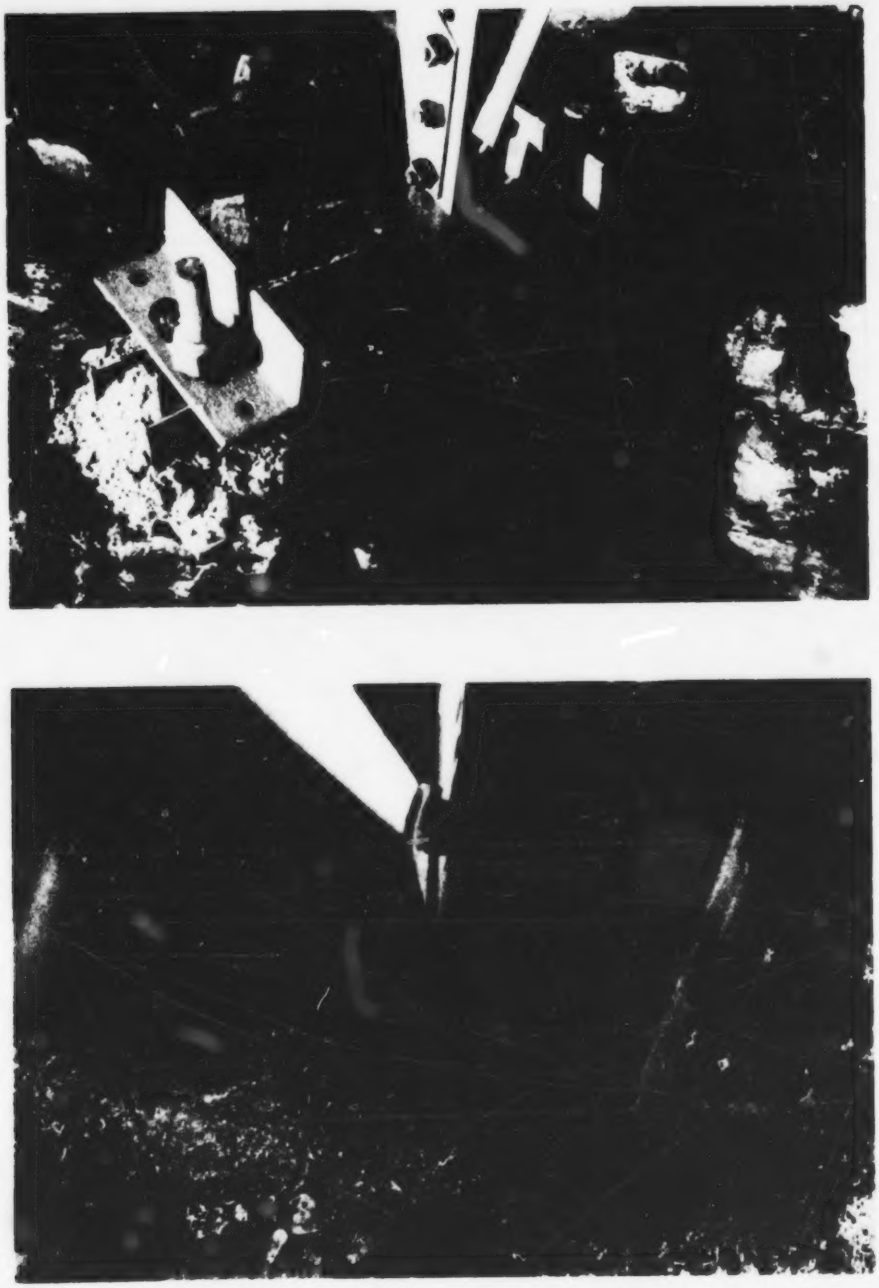


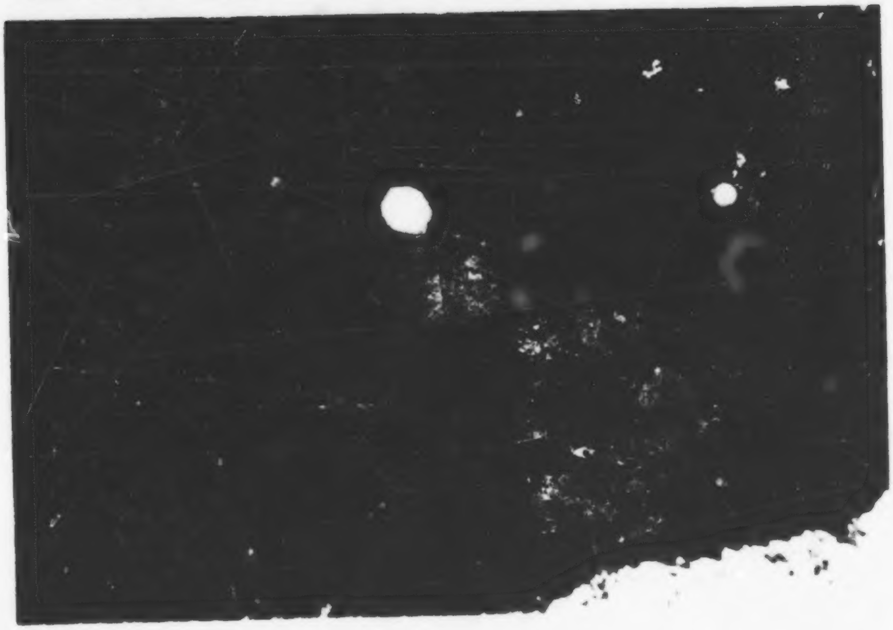
FIGURE A5

TYPICAL ROCK ANCHOR FOUNDATION ON "BALD ROCK" (TOWER # 138)
VISIBLE SIGNS OF CONCRETE DETERIORATION WAS EVIDENT

10 Tsang
Jana Disc

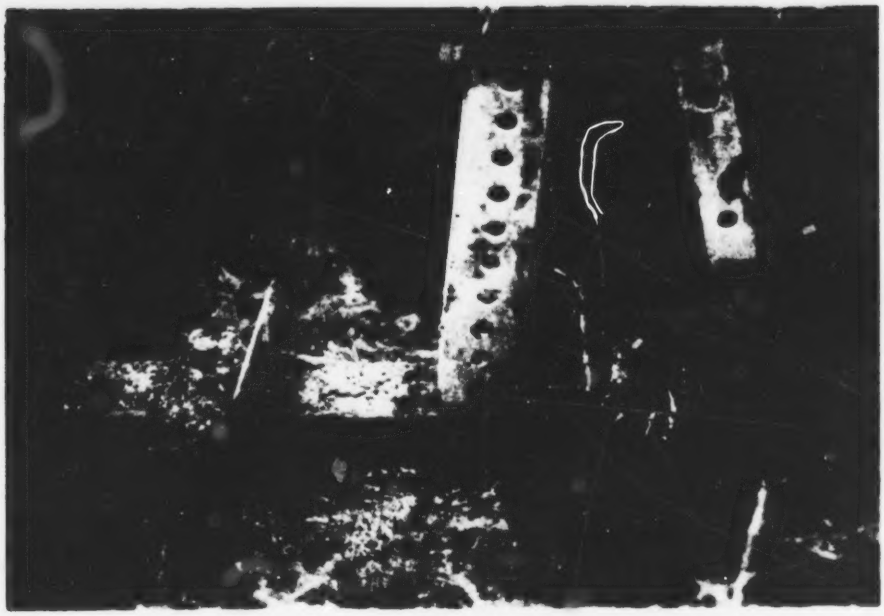
FIGURE A6

TOWER # 83
CORROSION ALONG MAIN LEG
AND BRACING AT DEPTH 2-3 ft



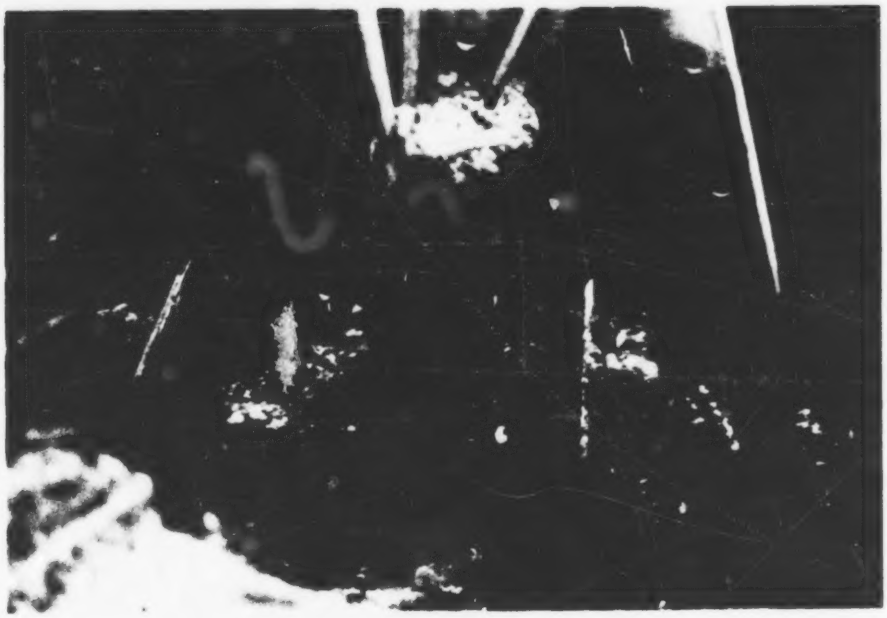
ONLY ONE ROCK ANCHOR BOLT WAS USED FOR THIS TOWER LEG
INSTEAD OF THE USUAL PAIR OF ANCHORS

11 Tsang
Jana Disc



TOWER # 66

SURFICIAL RUST ON CROSS-MEMBER NOT SEEN ON MAIN TOWER LEG ABOVE GROUND SURFACE



TOWER # 67

ROCK ANCHOR FOUNDATIONS EXCAVATED WITH 1 TO 2 ft OVERBURDEN

FIGURE A7

12 Tsang
Jana Disc

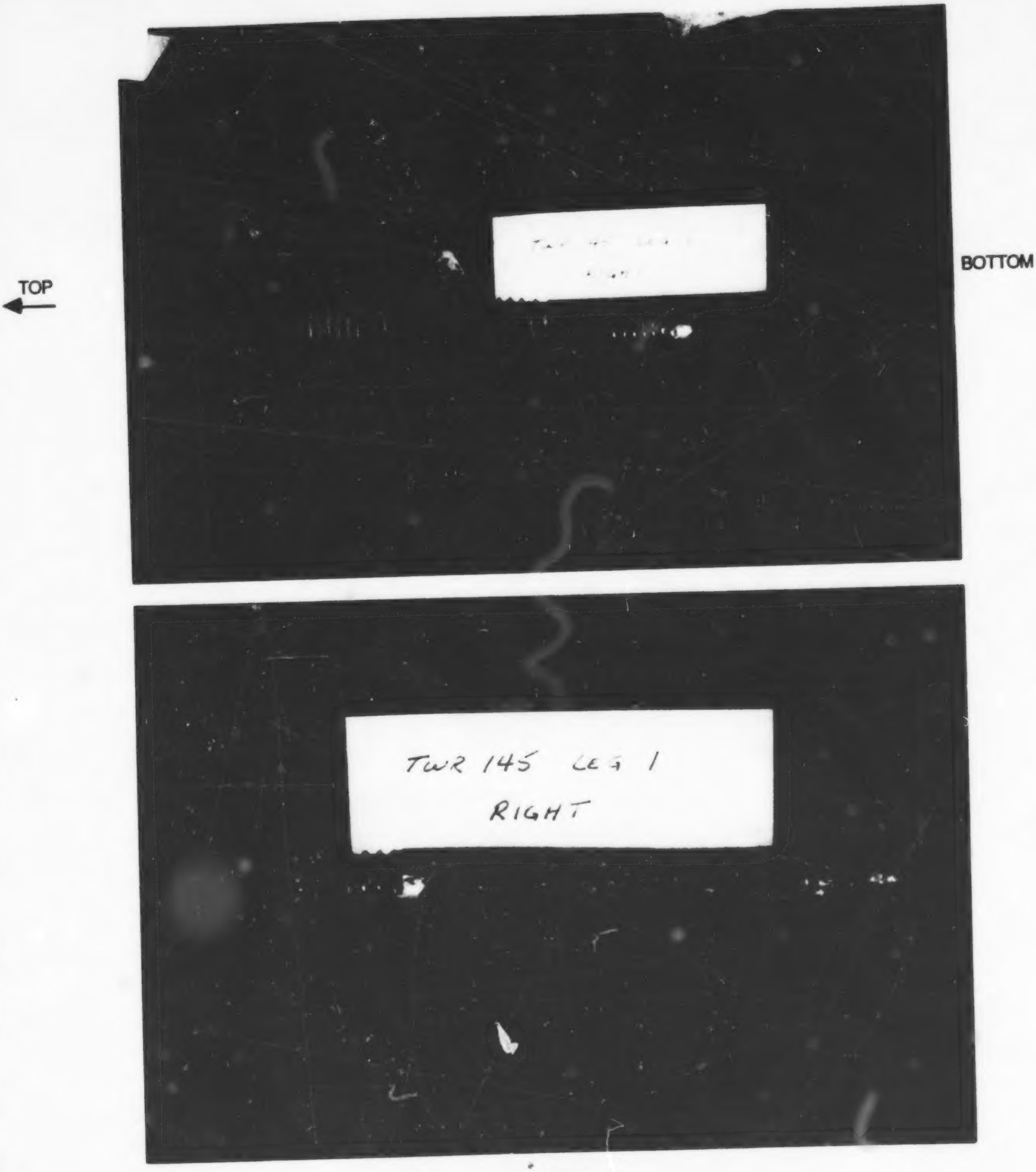

TOP
BOTTOM
TWR 145 LEG 1
RIGHT
TWR 145 LEG 1
RIGHT

FIGURE A8

TOWER # 145 LEG 1 RIGHT ROCK ANCHOR

ROCK ANCHOR SAMPLE WITH THE BROKEN TOP PORTION FROM PULLOUT TEST AND BOTTOM EMBEDDED LENGTH OF ANCHOR. NOTE SMOOTH STEEL SHAFT OF MECHANICAL (WEDGE-TYPE) ROCK ANCHOR. MINIMAL SURFICIAL RUST OBSERVED ON THE NUT AND BOTH SEGMENTS OF THE ROCK ANCHOR

13 Tsang
Jana Disc

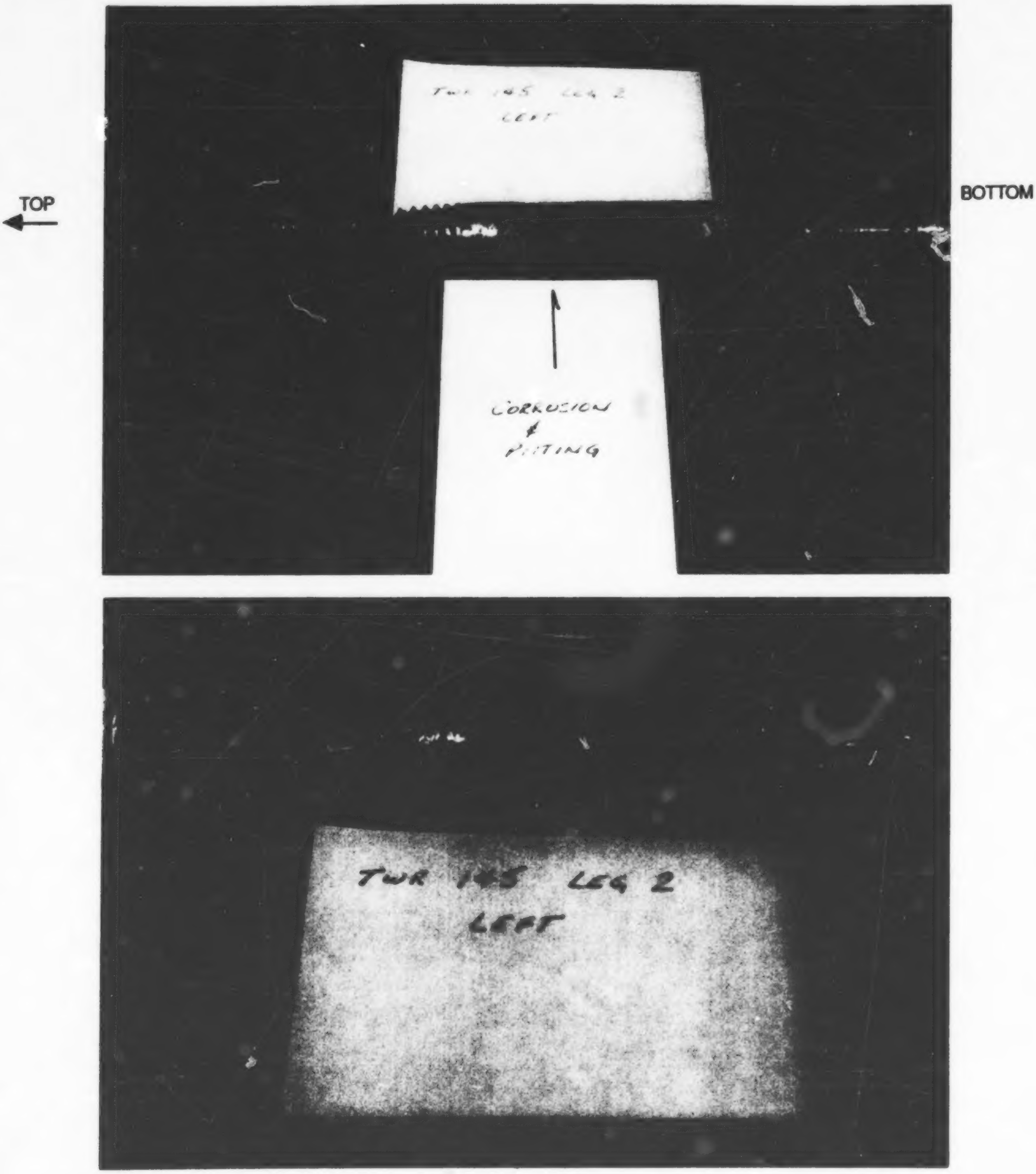

TOP
TWR 145 LEG 2
LEFT
BOTTOM
CORROSION
&
PITTING
TWR 145 LEG 2
LEFT

FIGURE A9

TOWER # 145 LEG 2 LEFT ROCK ANCHOR

SHOWS CORROSION AND PITTING NEAR BEDROCK SURFACE ALONG THE LOWER PORTION
THE TOP PORTION OF THE ROCK ANCHOR ABOVE GROUND INDICATES
LITTLE/MINIMAL CORROSION OCCURRED.

TOP
BOTTOM
TWR 145 LEG 2
LEFT

FIGURE A10

VARIABILITY EXISTS IN THE EXTENT OF CORROSION AND/OR PITTING OF ROCK ANCHOR FOUNDATIONS AT THE SAME TOWER SITE (TOWER #145 LEG 1 AND 2). THE FACTORS AFFECTING THE RATE OF CORROSION TEND TO BE SITE SPECIFIC

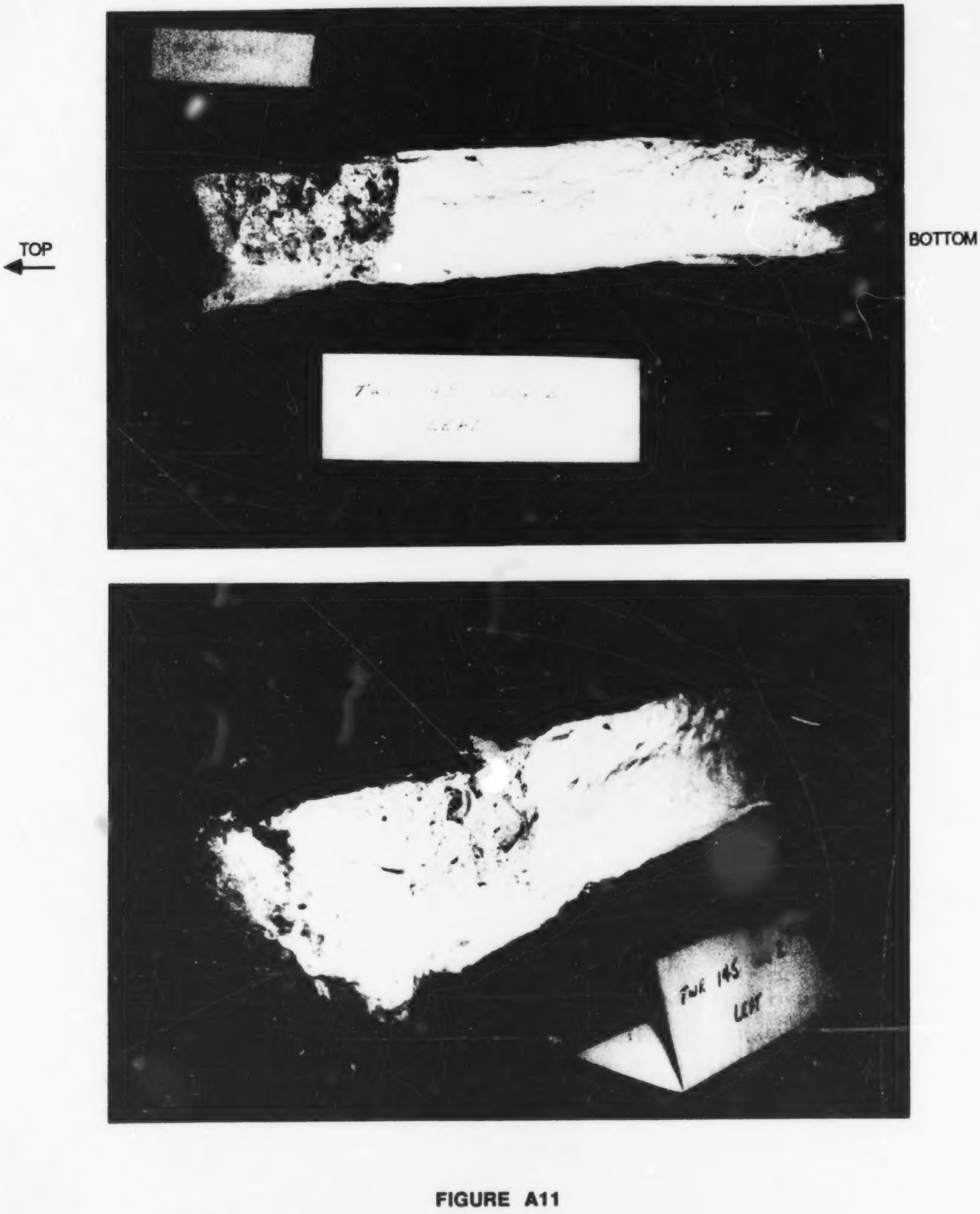

TOP
BOTTOM
TWR 145
LEFT

FIGURE A11

4" DIAMETER OVERCORE SAMPLE OF BEDROCK AND GROUT COLUMN TAKEN AT TOWER # 145 LEG 2 LEFT ROCK ANCHOR

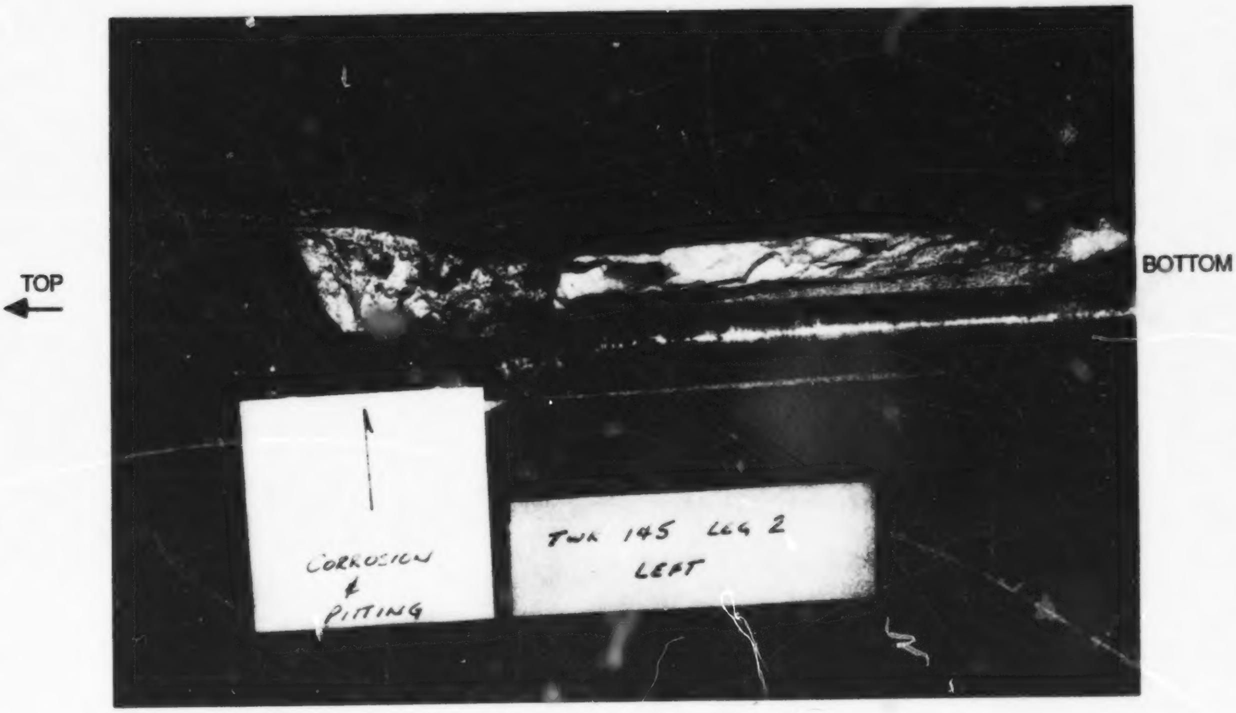


FIGURE A12

TOWER # 145 LEG 2 LEFT ROCK ANCHOR

TOP PORTION OF OVERCORED SAMPLE SHOWS SOME CONCRETE FILLED THE DRILL HOLE DURING THE ROCK ANCHOR INSTALLATION. THIS CONCRETED ZONE ALSO COINCIDES WITH THE EXTENSIVE CORROSION AND PITTING FOUND ON THE LOWER PORTION OF THE ROCK ANCHOR

THE LOWER PORTION OF THE OVERCORED SAMPLE SHOWS THE GROUT USED TO FILL THE DRILL HOLE DURING INSTALLATION. AS NOTED EARLIER, THE LOWER PORTION OF THE ROCK ANCHOR INDICATES MINIMAL CORROSION AT DEPTH IN THIS CASE.

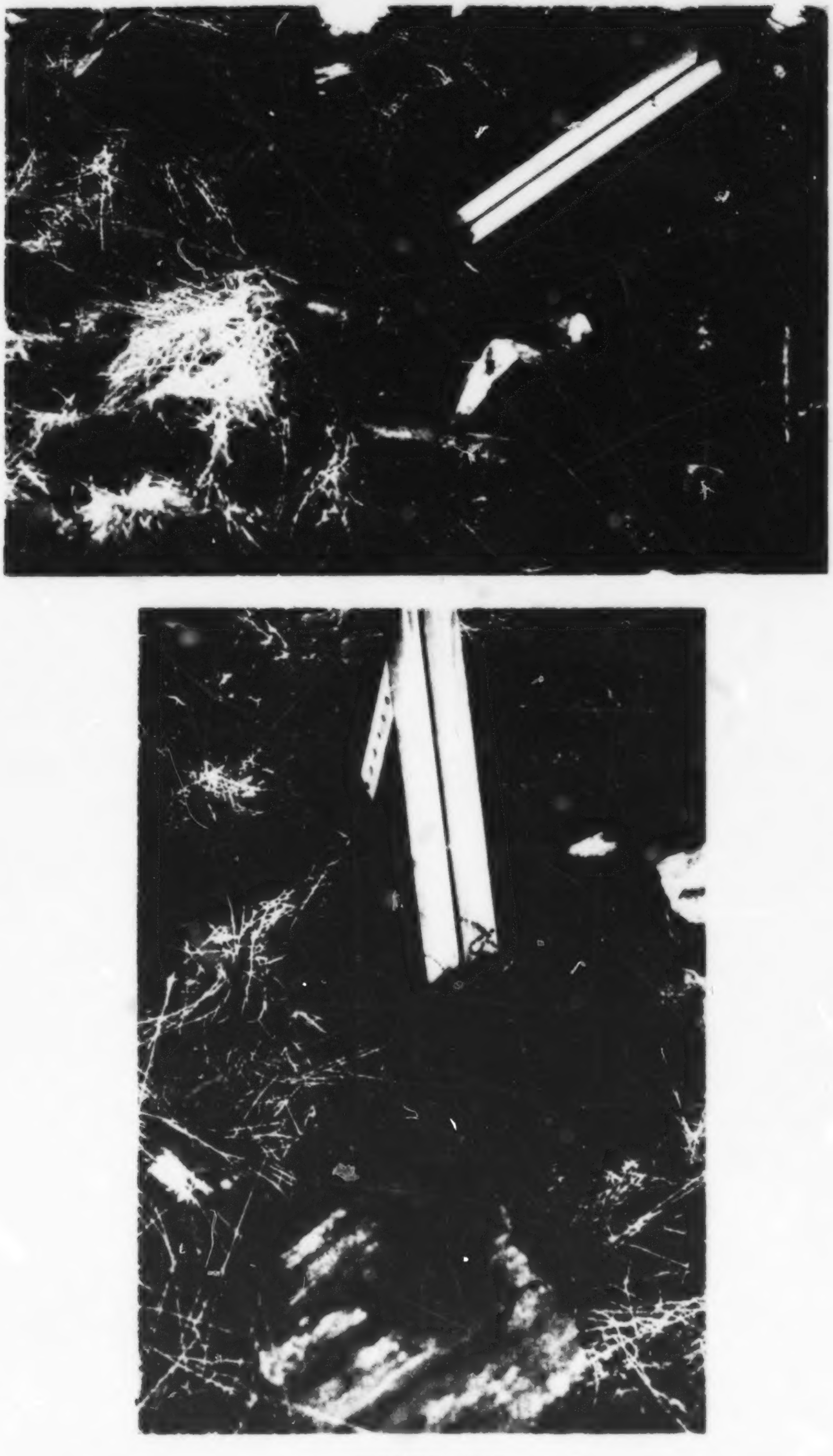
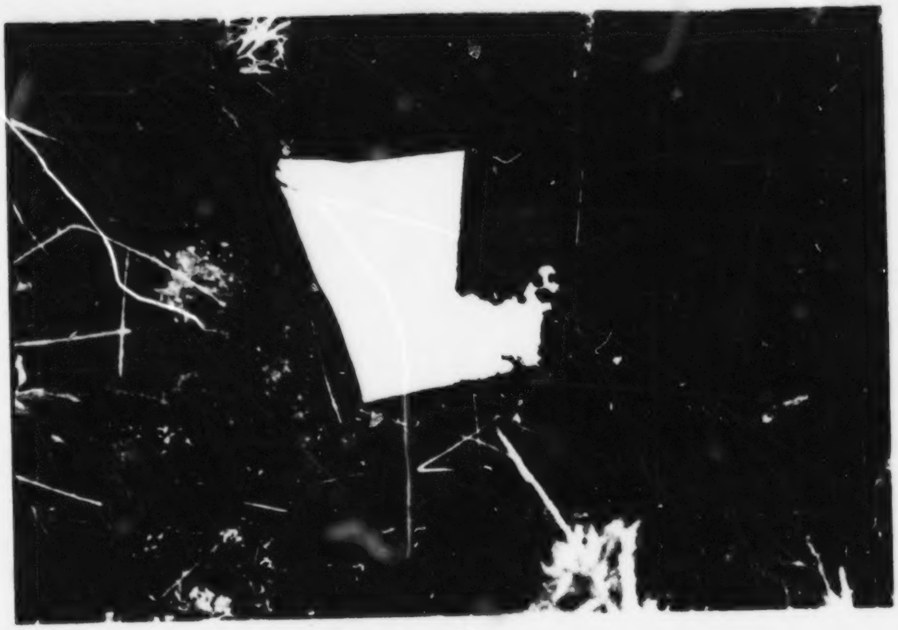


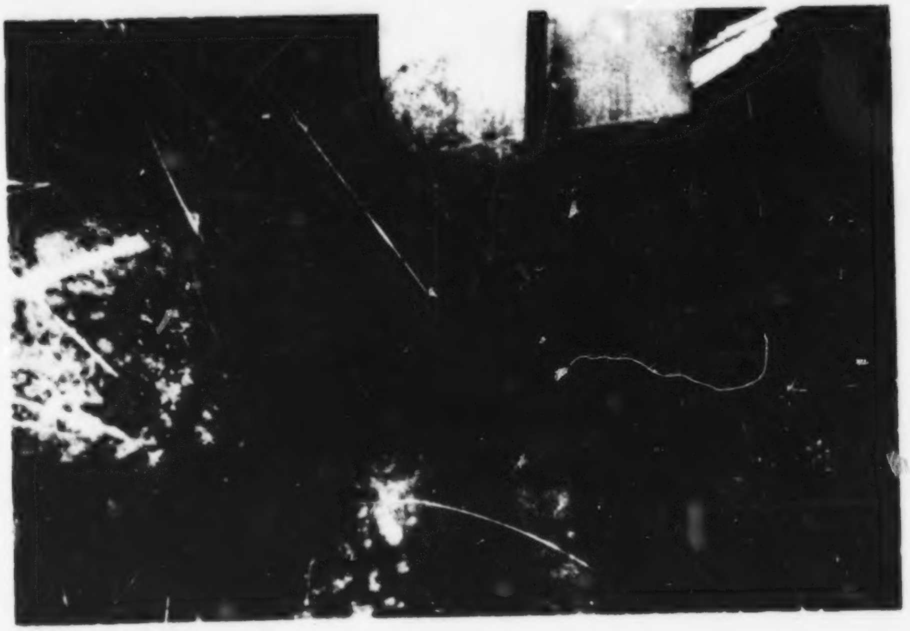
FIGURE A13

PONDING AROUND TOWER LEG AT TOWER # 151 WITH EVIDENCE OF EXCESSIVE CORROSION OF SIDE BRACING MEMBER

18 Tsang
Jaba Dusc



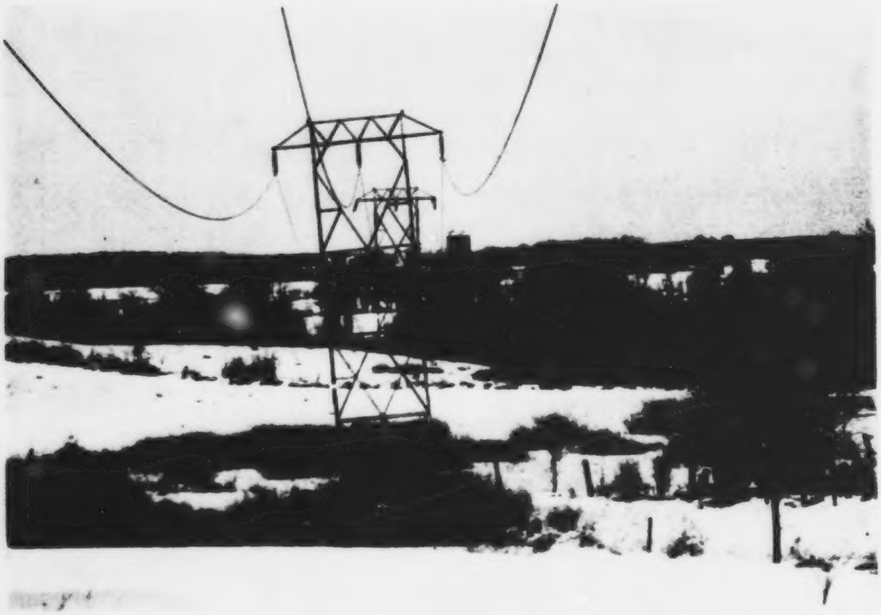
DEPRESSION AROUND THE TOWER LEG WITH DAMP SOIL, MOSS AND ROCKS



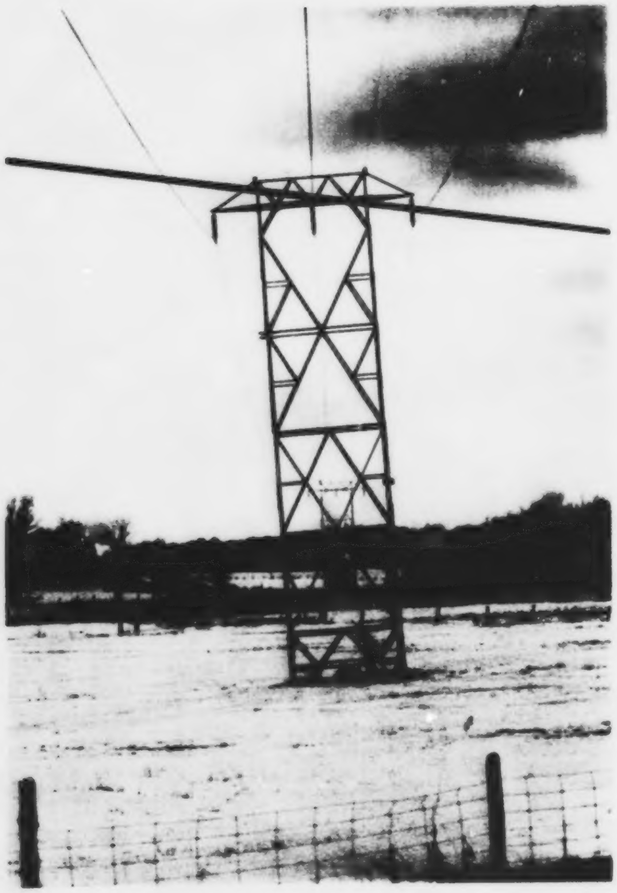
DEPRESSION AROUND TOWER LEG FILLED WITH WATER DUE TO SNOW MELTING

FIGURE A14

EXCESSIVE CORROSION OF A BRACING MEMBER NEAR GROUND SURFACE AT TOWER # 151



TOWER # 224



TOWER # 216

FIGURE A15

LEANING 115 kV SIK
KINGSTON-TYPE TOWERS (FOREGROUND)
WERE NOTED AT SEVERAL LOCATIONS
IN OPEN FIELDS

4 Tsang
Jana Disc

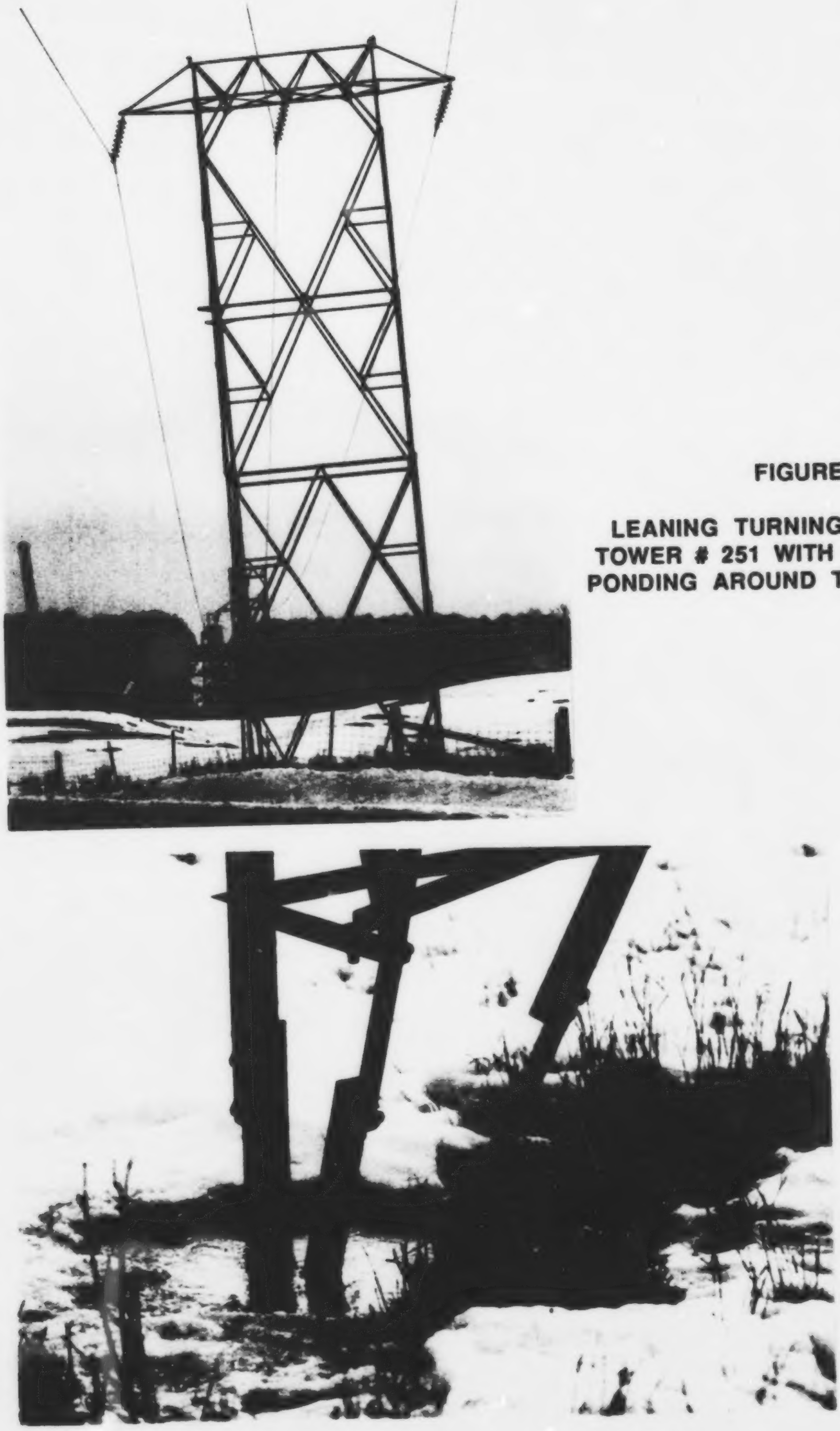


FIGURE A16

LEANING TURNING/ANGLE 115 kV TOWER # 251 WITH WATER AND ICE PONDING AROUND THE TOWER LEGS

5 Tsang
Jana Disc

APPENDIX B

TOWER FOUNDATION CORROSION STUDY

ontario hydro

Research Division
800 Kipling Avenue. Toronto. Ontario. Canada M8Z 5S4

MEMORANDUM

May 11, 1988

DR. H.S. RADHAKRISHNA
Senior Engineer
Soil Sciences Section
KR252

827.47 (T)

Transmission Line Refurbishment Study
Tower Foundation Corrosion Survey

INTRODUCTION

Three grillages from towers 84 and 143 and a leg from tower 83 held by a rock bolt were returned from Smiths Falls after the towers had been tested to destruction. These components as well as anchor bolts from tower 145 were examined for corrosion.

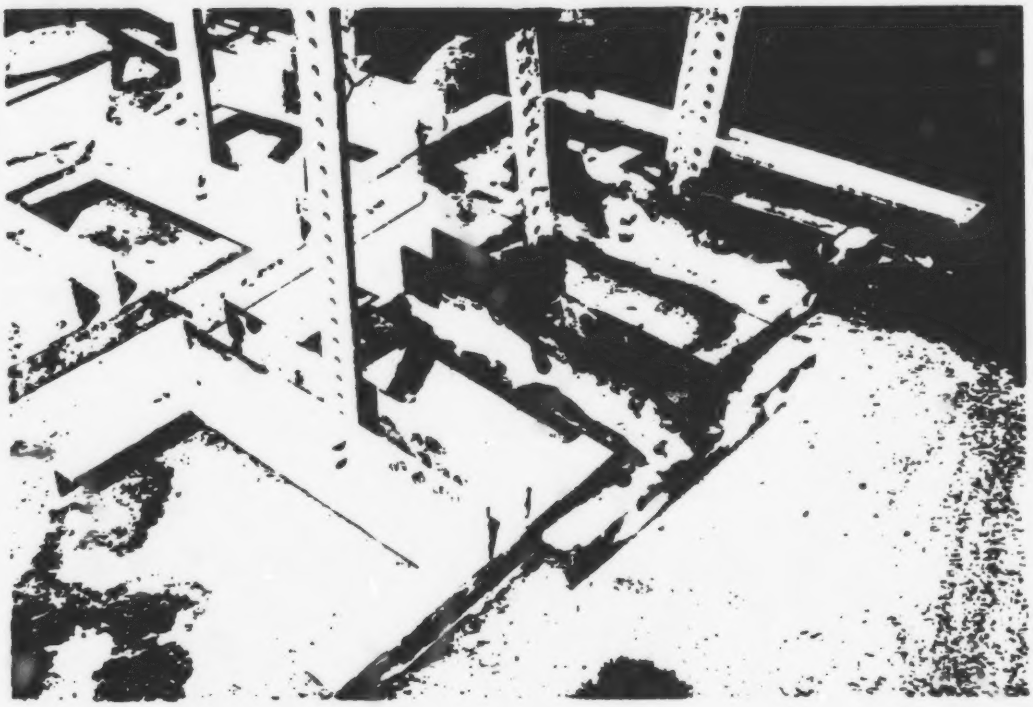
Soil samples from tower 84 and 143 were analyzed for corrosivity. Thickness measurements of the remaining galvanizing were also made on the sections of tower 84 and 143.

RESULTS OF EXAMINATION

The three grillages from tower 143 showed the most corrosion of the underlying steel. The galvanizing had completely corroded away on the undersides of the grillages of leg 2 and leg 3 and partially on leg 1. Areas of galvanizing were still intact on the upper surfaces of the grillages and the legs.

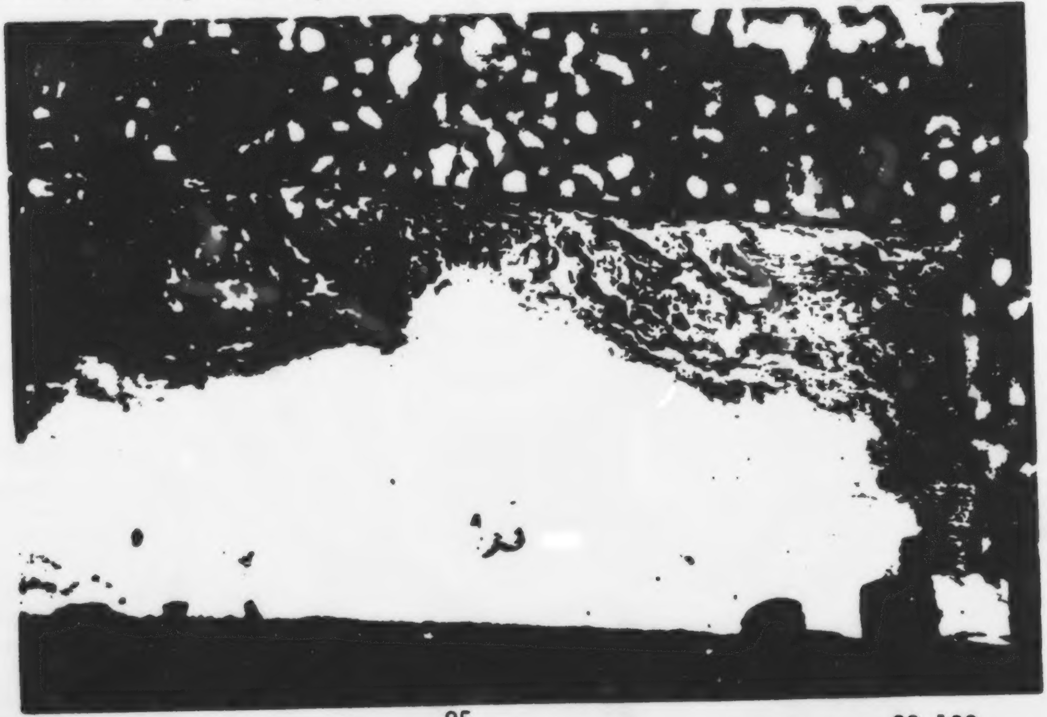
The grillages of tower 84 were still being almost completely protected by the galvanizing.

The following photograph shows the difference in the extent of corrosion at the two towers.



The three grillages at tower 143 are on the right and the three grillages of tower 84 are on the left.

When the corrosion product was removed from tower 143, leg 2, pits 0.03" deep were exposed as shown in the following photograph.



Leg 3 of tower 83 that was held by rock bolts was showing a partial loss of galvanizing at the sharp edges of members of the structure. There was an insignificant loss of underlying steel.

Of the anchor bolts inspected, only one from tower 145, leg 2, bolt 1 showed any corrosion of the underlying steel. The major corrosion extended about 3 inches below the threads. The rod had lost 8.3% of its diameter at the point of greatest corrosion.

The soil analysis for corrosivity showed that the soil at tower 143 was more corrosive than the soil at tower 84 due to its more acidic pH and lower resistivity.

The results of the analysis were as follows:

	Tower 143	**Tower 84**
Resistivity Ω.cm	6800	8900
pH	6.1	8.7
Moisture (saturated/damp/dry)	saturated	saturated
Sulphide Present (yes/no)	no	no

The thickness of the remaining galvanizing was measured at a number of locations on the components exposed to the atmosphere and the components exposed to the soil with the following results.

AVERAGE THICKNESS OF REMAINING GALVANIZING IN MILS (0.001 INCHES) ON COMPONENTS > 1/4 INCH THICK

	Leg 1	**Leg 2**	**Leg 3**
Tower 143 (Above Ground)	4.4		
Tower 143 (On the Grillages)	3.4	3.1	3.6
Tower 84 (Above Ground)	3.8		
Tower 84 (On the Grillages)	4.6	5.3	4.5

CONCLUSION

The corrosion rate of the grillages exposed to soil for 60 years is very low. The galvanizing has given good protection to the underlying steel.

The thickness readings, greater than 3.9 mils would still meet the ASTM specification for this type of product. Tower 143 above ground and tower 84 on the grillages steel meets this specification.

In areas where the galvanizing has been corroded away, the tower grillages will be corroding as bare steel. This corrosion rate will be greater than that of galvanized steel, but the precise rate is not known.

The soil analysis at the level of the grillages has been a good predictor of the corrosiveness of the soil or at least allowed rating the two soils in order of corrosivity.

An examination of the tower footing steel just a couple of feet from the surface would not have resulted in finding this difference in corrosivity.

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(Ext 6687)

ACH:km

cc W. Shmayda
R.H. Tsang, KR252
A.G. Verauer, KR252
P.G. Buchan, KR267

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MEMORANDUM

June 24, 1988

DR. H.S. RADHAKRISHNA
Senior Engineer
Soil Sciences Section
Civil Research Dept, KR252

File: 827.47 (T)

Transmission Line Refurbishment Study
Tower Foundation Corrosion Survey
Examination of Nuts, Bolts and Washers

INTRODUCTION

Seven bolts were removed from the grillages of tower 143 to examine them for corrosion.

Due to the shape of the components examined, it is not possible to accurately state the loss of metal in numerical values but only in comparative values.

RESULTS AND EXAMINATION

All the nuts and bolts were easy to remove from the components of the grillages.

Leg 1 - Least Corroded Grillage

One bolt examined. Zinc was still present on all the surfaces of the nut, bolt and washer. There is 5 mils of galvanizing left on the nuts. There is slight recent mechanical damage to the threads.

Leg 2 - Moderated Corroded Grillage

Two bolts examined. The heads of the bolts exposed to the soil are slightly corroded. The base metal of the nuts, lockwashers and body of the bolts are uncorroded.

Leg 3 - Moderately Corroded Grillage

One bolt examined. The protective galvanized coating has gone from the exposed parts of the nut, bolt and washer. The underlying steel is just starting to corrode. The threads on the bolt were recently mechanically damaged.

Leg 2 - Most Corroded Grillage

Three bolts examined. The protective galvanizing has nearly all gone from the exposed parts of the nuts, bolts and washers. The underlying steel is slightly corroded. The end or first thread on each bolt has been partially corroded away. The threads on one bolt were recently mechanically damaged.

CONCLUSION

The corrosion rate of the nuts, bolts and washers exposed to soil for 60 years is very low.

A C Headon

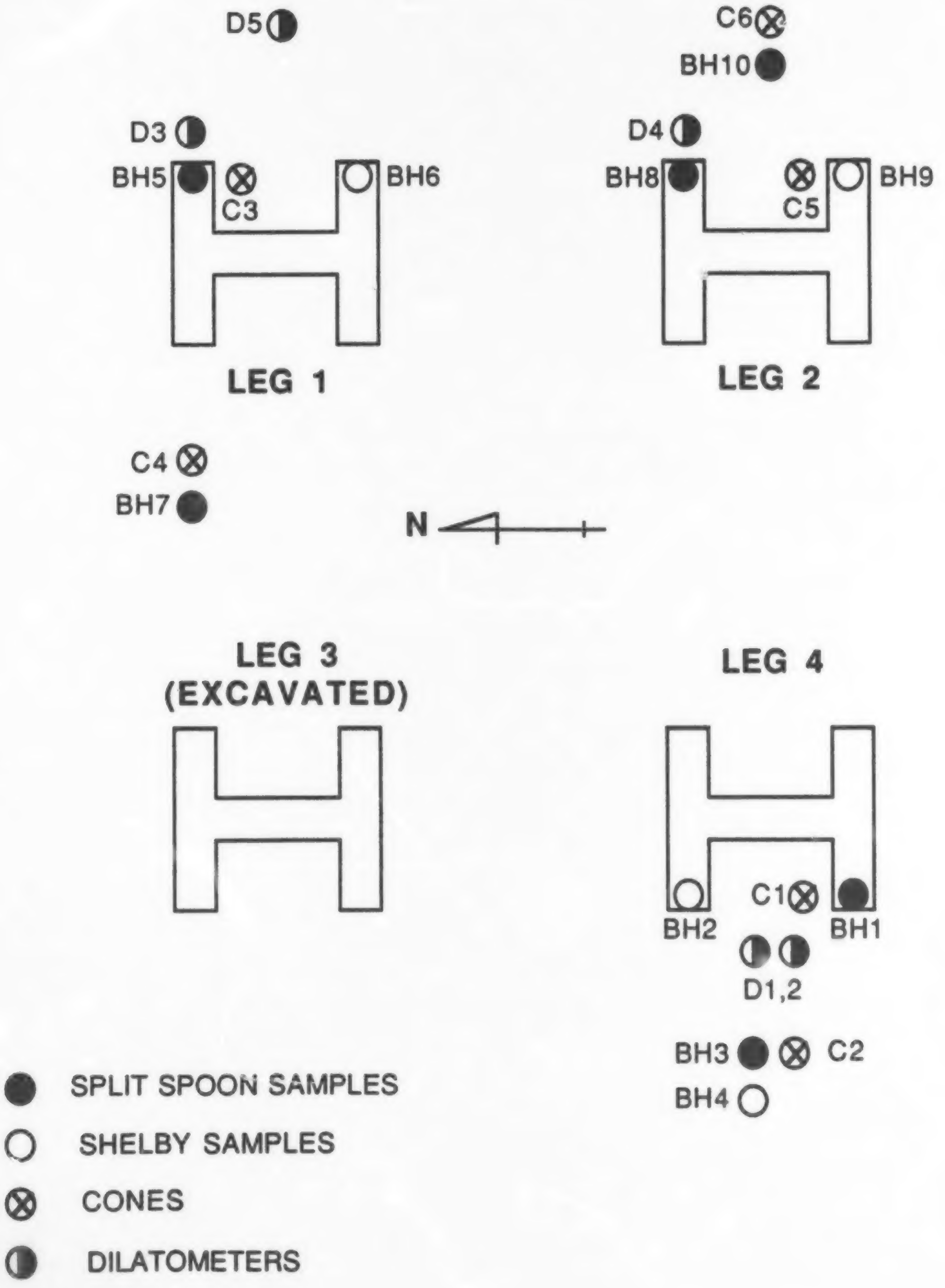
A.C. Headon
Senior Technologist
Corrosion & Tritium Technology Section
Metallurgical Research Department
(Ext 0+405+6687)

cc W.T. Shmayda
R.H. Tsang
A.G. Vorauer
P.G. Buchan

APPENDIX C

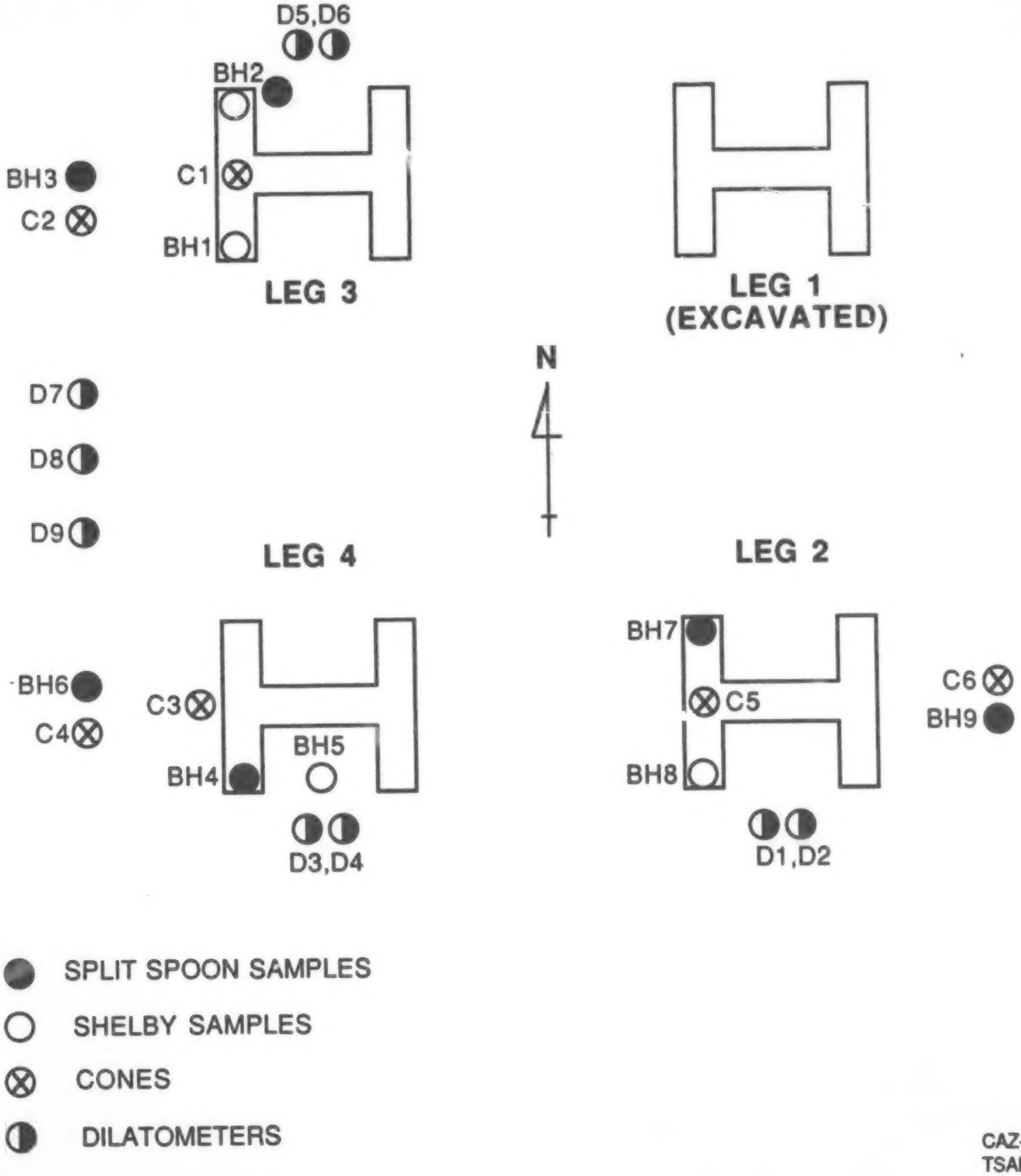
GEOTECHNICAL INVESTIGATION OF NATIVE SOIL AND GRILLAGE BACKFILL MATERIAL AT SELECTED SITES

FIGURE C1
TL REFURBISHMENT STUDY
TWR 84 GRILLAGE TESTS


D5
C6
BH10
D3
D4
BH5
C3
BH6
BH8
C5
BH9
LEG 1
LEG 2
C4
BH7
N
LEG 3
(EXCAVATED)
LEG 4
C1
BH2
BH1
D1,2
BH3
C2
BH4
● SPLIT SPOON SAMPLES
○ SHELBY SAMPLES
⊗ CONES
◐ DILATOMETERS

CAZ-3
TSANG-1

FIGURE C2
TL REFURBISHMENT STUDY
TWR 143 GRILLAGE TESTS


D5,D6
BH2
BH3
C1
C2
BH1
LEG 3
LEG 1
(EXCAVATED)
N
D7
D8
D9
LEG 4
LEG 2
BH7
BH6
C3
C5
C6
C4
BH9
BH5
BH4
BH8
D3,D4
D1,D2
● SPLIT SPOON SAMPLES
○ SHELBY SAMPLES
⊗ CONES
◑ DILATOMETERS

CAZ-3
TSANG-2

PROJECT.... *Lennox - Hawthorne T.L.*
LOCATION *TWR 84 Grillage Backfill*
Leg 4
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED *Jan 19/88*
DRAWN *A.M.*
OBSERVER *A.M.*
COMPILED
CHECKED
APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES	ELEV / DEPTH	(1) SAMPLE I/D	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
		1		*8*		*Fill, Silty Sand, Loose, Moist, Little Fine to Medium Gravel, Trace of Clay*						*1631*	*16.2*				
	0.5																
		2		*5*									*14.7*				
	1.0																
	1.5	*3*		*8*									*15.9*				
						END OF BOREHOLE 1.8 m											
	2.0																

GEOTECHNICAL DATA SHEET

hole no *BH1*

Fig *C3*

sheet

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 84 Grillage Backfill
Leg 4
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 19/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA					BORING LOG		WATER INF		FIELD TESTS		LABORATORY TESTS					
ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' sed/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS ϕ	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
	1	■	Push		Fill, Clay, Stiff, Brown, Moist Organics						1850	15.1				
0.5					Fill, Silty Sand, Compact, Brown, Moist, Little Clay											
1.0	2	■	Push								1911	14.8				
1.5	3	■	Push								1820	17.5				
					END OF BOREHOLE 1.8 m											
2.0																

GEOTECHNICAL DATA SHEET

hole no BH2

Fig C4

sheet

PROJECT Lennox - Hawthorne T.L.		HOLE TYPE	OBSERVER A.M.
LOCATION TWR 84 Native Soil		HOLE SIZE	COMPILED
Leg 4	DIP	DRILLED Jan 19/88	CHECKED
DATUM	BEARING	DRAWN A.M.	APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)				(10)		(11)	
SCALE - METRES	ELEV DEPTH	SAMPLE NO	SAMPLE TYPE	'N' VALUE per 0.3m RQD-%	WATER LEVEL and CAVING W.R	DESCRIPTION	REMARKS	OBSERVATION WELL DATA	'k' soil/rock cm/s WATER PRESS TEST	SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	SHEAR STRENGTH kPa TYPE	RESULTS	SPECIAL TESTS TYPE	RESULTS
		1		15		Native, Clay, Compact, Brown, Moist, Organics, Trace of Silt & Sand							34.1				
	0.5																
		2		16		Native, Sand, Compact, Brown, Moist, Little Clay & Fine to Coarse Gravel							18.2				
	1.0																
	1.5	3		26									12.6				
						END OF BOREHOLE 1.75 m											
	2.0																

dwg no

	GEOTECHNICAL DATA SHEET	hole no BH3	Fig C5
		sheet	

PROJECT	Lennox - Hawthorne T.L.	HOLE TYPE		OBSERVER	A.M.
LOCATION	TWR 84 Native Soil	HOLE SIZE		COMPILED	
	Leg 4	DIP		CHECKED	
		DRILLED	Jan 19/88		
DATUM		BEARING		APPROVED	
		DRAWN	A.M.		

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)				(10)		(11)	
SCALE - METRES	ELEV DEPTH	SAMPLE NO	SAMPLE TYPE	'N' VALUE per 0.3m RQD - %	WATER LEVEL and CAVING W.R	DESCRIPTION	REMARKS	OBSERVATION WELL DATA	'k' soil/rock cm/s WATER PRESS. TEST	SPECIAL TESTS TYPE	SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	SHEAR STRENGTH kPa TYPE	SHEAR STRENGTH kPa RESULTS	SPECIAL TESTS TYPE	SPECIAL TESTS RESULTS
	0.5																
		1	■	Push		Native, Clay, Stiff, Brown, Moist, Organics							33.8				
	1.0																
		2	■	Push		Silty Sand, Stiff, Brown, Moist, Some Clay, Little Fine to Coarse Gravel							11.6	u/c	34.7		
	1.5																
						END OF BOREHOLE 1.7 m											
	2.0																

GEOTECHNICAL DATA SHEET

hole no BH4

Fig C6

sheet

PROJECT Lennox - Hawthorne T.L.

LOCATION TWR 84 Grillage Backfill
Leg 1

DATUM

DIP

BEARING

HOLE TYPE

HOLE SIZE

DRILLED Jan 19/88

DRAWN A.M.

OBSERVER A.M.

COMPILED

CHECKED

APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE - METRES	ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
		1		5		Fill, Silty Sand, Loose, Brown, Moist, Little Clay							19.0				
	0.5																
		2		7									15.3				
	1.0																
	1.5	3		5									14.1				
						END OF BOREHOLE 1.8 m											
	2.0																

GEOTECHNICAL DATA SHEET

hole no BH5

Fig C7

sheet

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 84 Grillage Backfill
Leg 1
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 19/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA					BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
					Augered Through Frost											
0.5																
	1		Push		Fill, Silty Clay, Stiff, Grey, Moist, Some Sand & Gravel						1950	15.3	u/c	61.0		
1.0																
	2		Push													
1.5					Augered Through Continuous Cobbles & Boulders						1495	16.1	u/c	39.9		
2.0					END OF BOREHOLE 2.0 m											

GEOTECHNICAL DATA SHEET

hole no BH6

Fig C8

sheet

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 84 Native Soil
Leg 1
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 19/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES	ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
	0.5					Auger Through Frost, then Cobble to 0.75 m											
	1.0	1		18		Native, Sand, Compact, Grey, Moist, Little Clay & Fine to Medium Gravel							12.3				
	1.5	2		16/100mm									11.2				
						END OF BOREHOLE 1.75 m											
	2.0																

GEOTECHNICAL DATA SHEET

hole no BH7

Fig C9

sheet

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 84 Grillage Backfill
Leg 2
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 19/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

SCALE-METRES	ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
		1		3		Fill, Silty Sand, Very Loose, Brown, Moist, Little Gravel & Cobbles							19.4				
	0.5																
		2		35/75 Bouncing									13.8				
	1.0					Auger Through Silty Sand, Cobbles & Boulders to 1.5 m											
	1.5																
		3		3		Fill, Silty Sand, Very Loose, Brown, Moist, Little Clay							15.2				
	2.0					END OF BOREHOLE 2.0 m											

GEOTECHNICAL DATA SHEET

hole no BH8

Fig C10

sheet

PROJECT Lennox - Hawthorne
LOCATION TWR 84 Grillage Backfill
Leg 2
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 20/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

SCALE-METRES	ELEV DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m ROD-%	(4) WATER LEVEL and CAVING W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
						Auger Through Frost											
	0.5		▮														
		1	▮	Push		Fill, Silty Sand, Compact, Brown, Moist						1797	15.8				
	1.0		▮														
		2	▮	Push													
	1.5					Auger Through Cobbles & Boulders to 2.0 m											
	2.0					END OF BOREHOLE 2.0 m											

GEOTECHNICAL DATA SHEET

hole no BH9

Fig C11

sheet

PROJECT Lennox-Hawthorne T.L.		HOLE TYPE	OBSERVER A.M.
LOCATION TWR 84 Native Soil		HOLE SIZE	COMPILED
Leg 2	DIP	DRILLED Jan 20/88	CHECKED
DATUM	BEARING	DRAWN A.M.	APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES	ELEV DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
		1		5		Native, Silty Sand, Loose to Dense, Grey, Moist, Little Clay, Trace Gravel							16.6				
	0.5																
		2		11									13.5				
	1.0																
	1.5	3		36/150									12.7				
						END OF BOREHOLE 1.75 m											
	2.0																

	GEOTECHNICAL DATA SHEET	hole no BH10	Fig C12
		sheet	

PROJECT Lennox-Hawthorne T.L.
LOCATION TWR 143 Grillage Backfill
Leg 3
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 21/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA					BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
ELEV DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
0.5	1	■			Fill, Silty Clay, Firm to Stiff, Moist, Sand Seams							24.5				
W.T. 1.0	2	■		▼	Fill, Fine to Coarse Sand, Moist, Little Clay & Silt							22.8				
1.5																
2.0	3	■			Native, Clay, Stiff, Brown, Moist, Little Sand & Silt							23.5				
					END OF BOREHOLE 2.3 m											
2.5																

GEOTECHNICAL DATA SHEET

hole no BH1

Fig C13

sheet

177451-RD

PROJECT Lennox-Hawthorne T.L.
LOCATION TWR 143 Grillage Backfill
Leg 3
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 21/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA					BORING LOG		WATER INF		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES	ELEV DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m RQD-%	(4) WATER LEVEL and CAVING W.R.	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
		1	X	8		Fill, Silty Sand, Loose, Brown, Moist, Organics											
	0.5												19.7				
		2	X	8		Fill, Silty Sand, Loose, Brown, Moist, Some Clay											
	1.0												20.7				
	1.5	3	X	3		Fill, Silty Clay, Very Loose, Moist, Some Fine to Medium Sand							24.6				
	2.0																
		4	X	3		Native, Fine to Coarse Sand, Very Loose, Brown, Wet, Some Silt & Clay							18.9				
						END OF BOREHOLE 2.4 m											
	2.5																

dwg no

GEOTECHNICAL DATA SHEET

hole no BH2

Fig C14

sheet

PROJECT *Lennox-Hawthorne T.L.*
LOCATION *TWR 143 Native Soil*
Leg 3
DATUM

HOLE TYPE
HOLE SIZE
DIP
BEARING
DRILLED *Jan 21/88*
DRAWN *A.M.*

OBSERVER *A.M.*
COMPILED
CHECKED
APPROVED

ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R.	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
	1		12		*Native, Silty Sand, Compact, Brown, Wet, Fine to Coarse Sand*							26.2				
0.5																
	2		22									30.4				
1.0																
1.5	3		10									20.3				
2.0					*Native, Fine to Coarse Sand, Brown, Wet*											
	4		8									16.6				
					END OF BOREHOLE 2.4 m											
2.5																

GEOTECHNICAL DATA SHEET

hole no *BH3*

Fig *C15*

sheet

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 143 Grillage Backfill
Leg 4
DIP
DATUM
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 21/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)				(10)		(11)	
SCALE-METRES	ELEV DEPTH	SAMPLE NO	SAMPLE TYPE	'N' VALUE per 0.3m RQD-%	WATER LEVEL and CAVING W.R	DESCRIPTION	REMARKS	OBSERVATION WELL DATA	'k' soil/rock cm/s WATER PRESS. TEST	SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	SHEAR STRENGTH kPa TYPE	RESULTS	SPECIAL TESTS TYPE	RESULTS
		1		6		Fill, Silty Clay, Compact, Grey, Moist						1885	25.7				
	0.5																
		2		11									24.5				
	1.0																
	1.5	3		7		Fill, Fine to Medium Sand, Brown, Wet							19.7				
	2.0																
		4		7									20.5				
						END OF BOREHOLE 2.4 m											
	2.5																

GEOTECHNICAL DATA SHEET

hole no BH4

Fig C16

sheet

PROJECT	Lennox-Hawthorne T.L.		HOLE TYPE		OBSERVER A.M.
LOCATION	TWR 143 Grillage Backfill		HOLE SIZE		COMPILED
	Leg 4	DIP	DRILLED	Jan 21/88	CHECKED
DATUM		BEARING	DRAWN	A.M.	APPROVED

BORING DATA					BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	(10) SHEAR STRENGTH kPa TYPE	(10) RESULTS	(11) SPECIAL TESTS TYPE	(11) RESULTS
	1		Push		Fill, Clay, Brown, Moist, Little Silt							27.7				
0.5																
	2		Push		Fill, Fine to Coarse Sand, Wet							26.9				
1.0																
1.5	3		Push									24.9				
2.0	4		Push		Native, Fine to Coase Sand, Moist							11.6				
					END OF BOREHOLE 2.4 m											
2.5																

GEOTECHNICAL DATA SHEET	hole no BH5	Fig C17	sheet

PROJECT Lennox - Hawthorne T.L.		HOLE TYPE	OBSERVER A.M.
LOCATION TWR 143 Native Soil		HOLE SIZE	COMPILED
Leg 4	DIP	DRILLED Jan 21/88	CHECKED
	BEARING	DRAWN A.M.	APPROVED
DATUM			

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES	ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' sod/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
						Native, Silty Sand, Compact, Organics, Little Fine to Medium Sand							24.0				
		1		6													
	0.5																
													25.6				
		2		23													
	1.0																
						Native, Fine to Coarse Sand, Compact, Brown, Wet							19.3				
	1.5	3		14													
													18.9				
	2.0																
		4		5													
						END OF BOREHOLE 2.4 m											
	2.5																

GEOTECHNICAL DATA SHEET	hole no BH6	Fig C18
	sheet	

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 143 Grillage Backfill
Leg 2
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 21/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA					BORING LOG		WATER INF		FIELD TESTS		LABORATORY TESTS					
ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS TEST	(9) SPECIAL TESTS TYPE	(9) SPECIAL TESTS RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	(10) SHEAR STRENGTH kPa RESULTS	(11) SPECIAL TESTS TYPE	(11) SPECIAL TESTS RESULTS
	1		7		Fill, Silty Clay, Compact Brown, Moist, Organics							28.0				
0.5																
	2		4									29.8				
1.0																
1.5	3		8		Fill, Fine to Coarse Sand, Compact, Wet							20.9				
2.0	4		20									20.9				
2.5					END OF BOREHOLE 2.4 m											

GEOTECHNICAL DATA SHEET

hole no BH7

Fig C19

sheet

PROJECT *Lennox - Hawthorne T.L.*
LOCATION *TWR 143 Grillage Backfill*
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED *Jan 21/88*
DRAWN *A.M.*
OBSERVER *A.M.*
COMPILED
CHECKED
APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE - METRES	ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / WR	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT - %	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
		1		Push		*Fill, Clay, Stiff, Brown, Moist*						1570	28.6				
	0.5																
				"													
	1.0	2										1729	27.0	Q/U	25.2		
	1.5			"		*Fill, Fine to Coarse Sand, Wet*											
		3										2000	22.1				
						END OF BOREHOLE 1.8 m											
	2.0																
	2.5																

GEOTECHNICAL DATA SHEET

hole no *BH8*

Fig *C20*

sheet

PROJECT Lennox - Hawthorne T.L.
LOCATION TWR 143 Native Soil
DATUM
DIP
BEARING
HOLE TYPE
HOLE SIZE
DRILLED Jan 21/88
DRAWN A.M.
OBSERVER A.M.
COMPILED
CHECKED
APPROVED

BORING DATA						BORING LOG		WATER INF.		FIELD TESTS		LABORATORY TESTS					
SCALE-METRES	ELEV / DEPTH	(1) SAMPLE NO	(2) SAMPLE TYPE	(3) 'N' VALUE per 0.3m / RQD-%	(4) WATER LEVEL and CAVING / W.R	(5) DESCRIPTION	(6) REMARKS	(7) OBSERVATION WELL DATA	(8) 'k' soil/rock cm/s / WATER PRESS. TEST	(9) SPECIAL TESTS TYPE	RESULTS	NATURAL DENSITY kg/m³	MOISTURE CONTENT-%	(10) SHEAR STRENGTH kPa TYPE	RESULTS	(11) SPECIAL TESTS TYPE	RESULTS
		1	☒	15		Native Silty Sand, Brown Compact, Moist							37.6				
	0.5																
		2	☒	17									29.2				
	1.0					Changing to Fine to Medium Sand											
	1.5	3	☒	20		Native, Fine to Coarse Sand, Compact, Brown, Wet							19.5				
	2.0																
		4	☒	14									13.6				
	2.5					END OF BOREHOLE 2.4 m											

GEOTECHNICAL DATA SHEET

hole no BH9

Fig C21

sheet

MECHANICAL ANALYSIS - TL REFURBISHMENT-SMITH FALLS, TWR# 84,BH-3,S-3

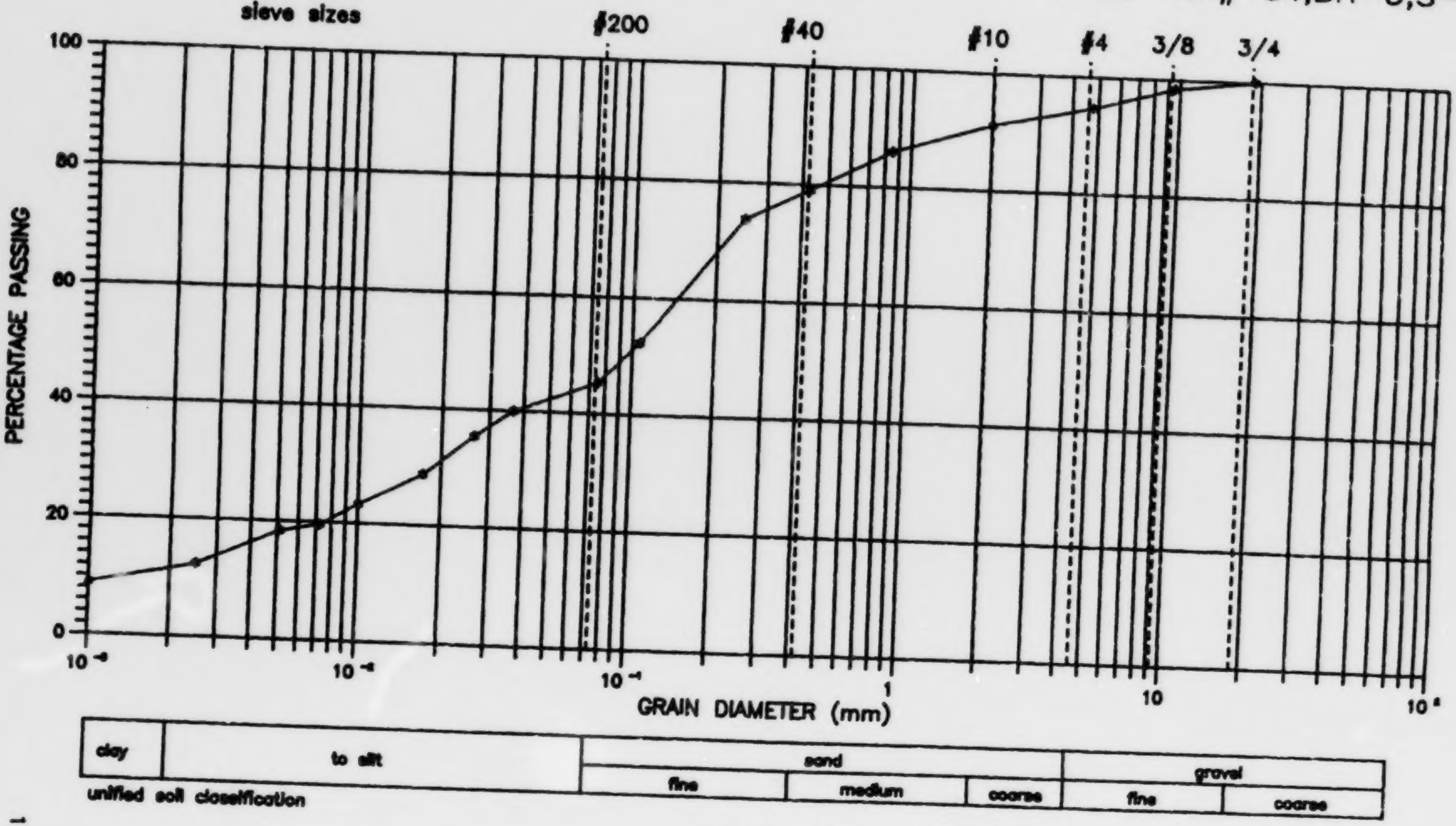


FIGURE C22

NATIVE SOIL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS -TL REFURBISHMENT-SMITH FALLS,TWR #84,BH-7,S-2.

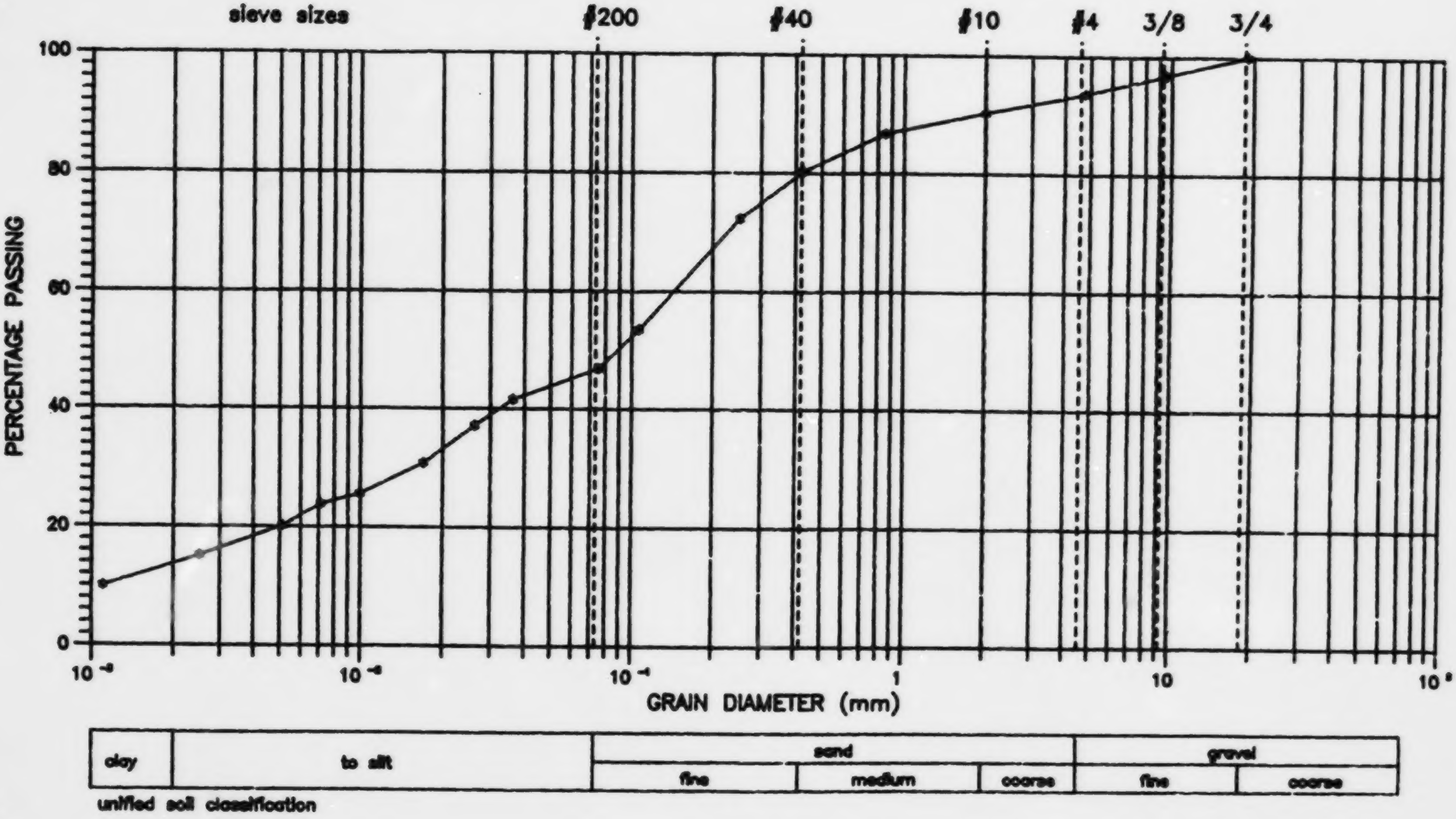


FIGURE C23
NATIVE SOIL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS – TL REFURBISHMENT–SMITH FALLS,TWR#84,BH–10,S–3.

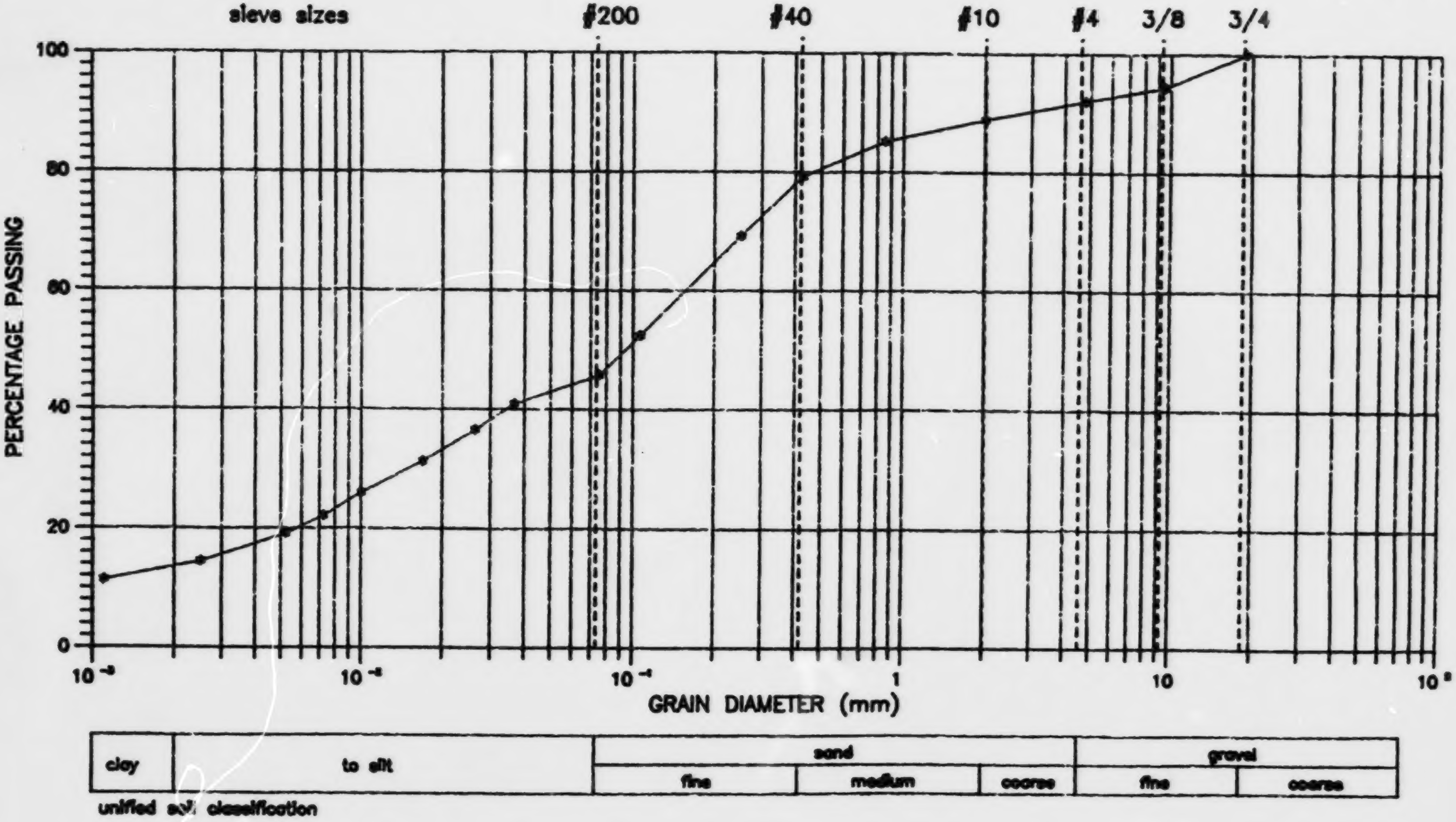


FIGURE C24

NATIVE SOIL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS – TL REFURBISHMENT–SMITH FALLS,TWR #84,BH–9,S–1.

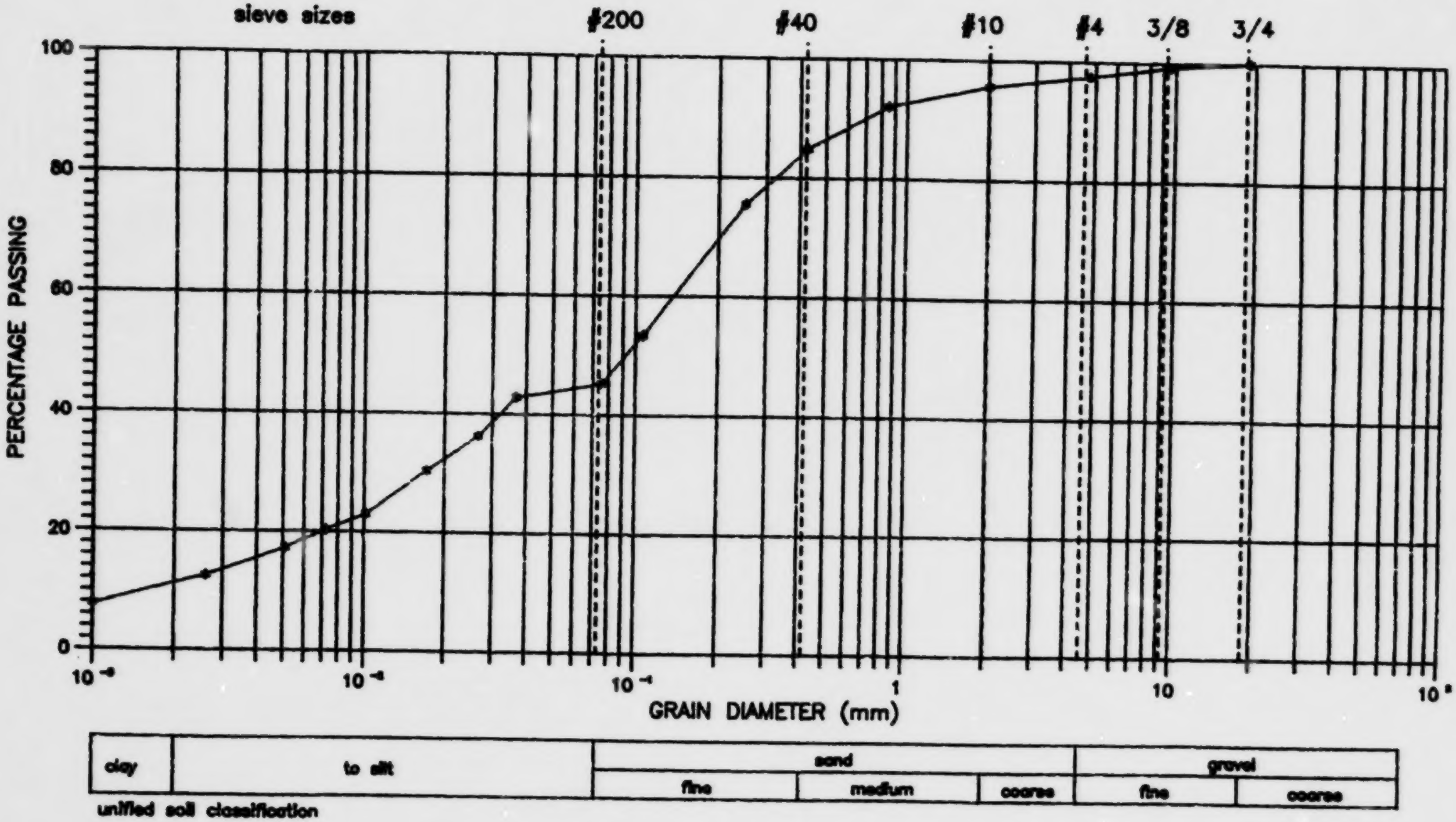


FIGURE C25

GRILLAGE BACKFILL MATERIAL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS - TL REFURBISHMENT-SMITH FALLS,TWR#84,LEG-3.

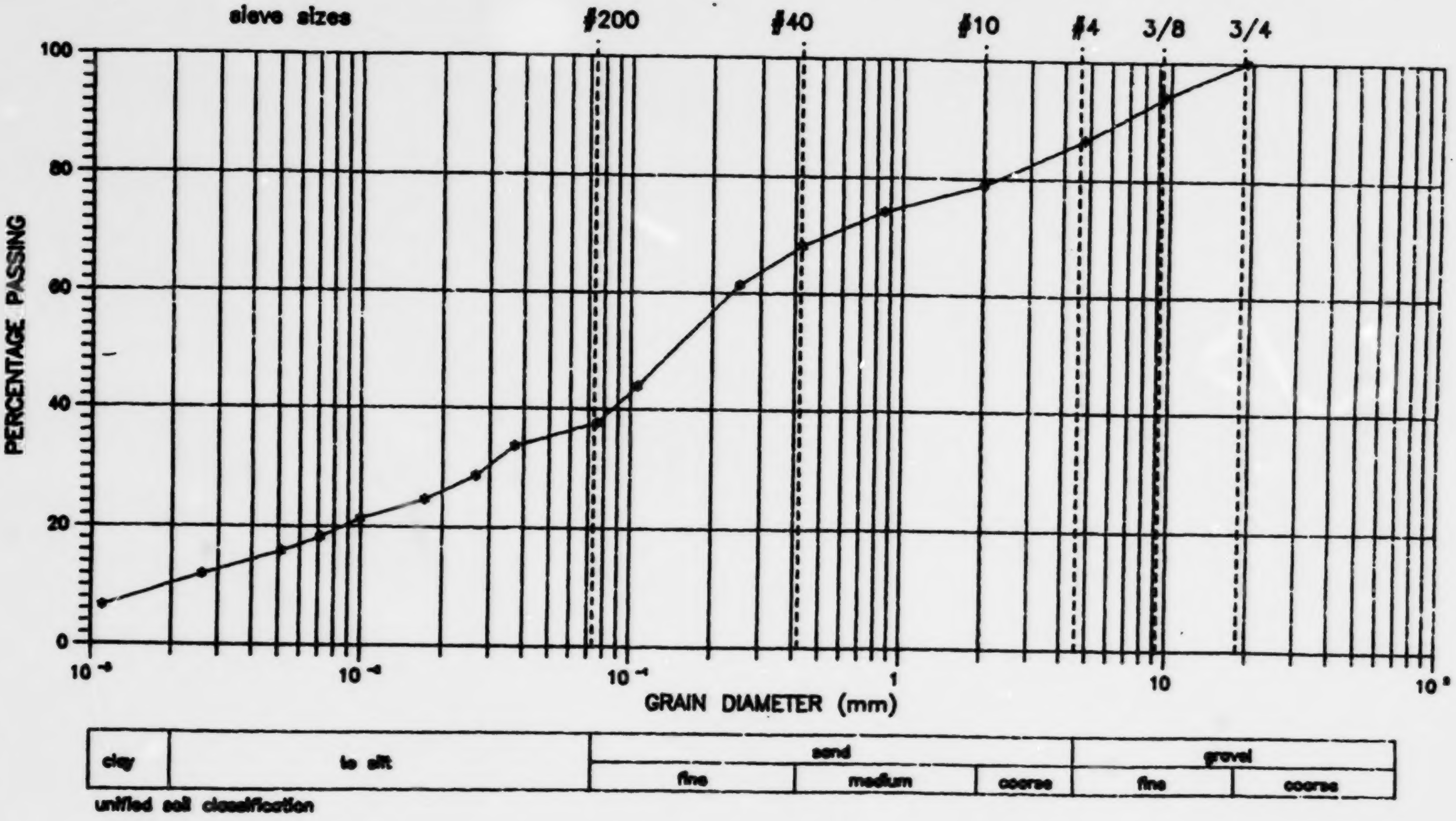


FIGURE C26

GRILLAGE BACKFILL MATERIAL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS – TL REFURBISHMENT – SMITH FALLS ,TWR# 143,BH–9,

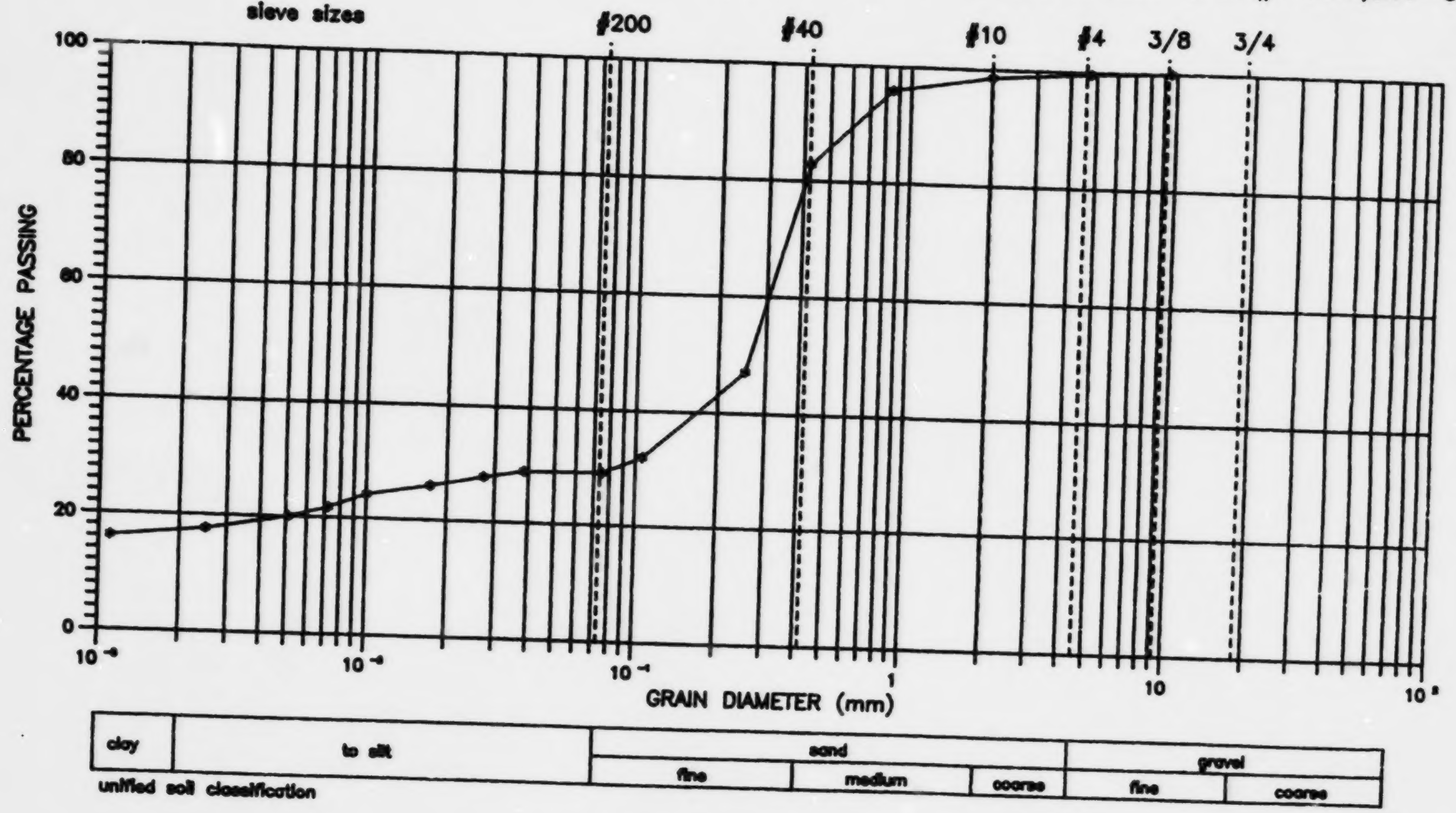


FIGURE C27
NATIVE SOIL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS – TL REFURBISHMENT –SMITH FALLS,TRW #143,BH–2,S–4.

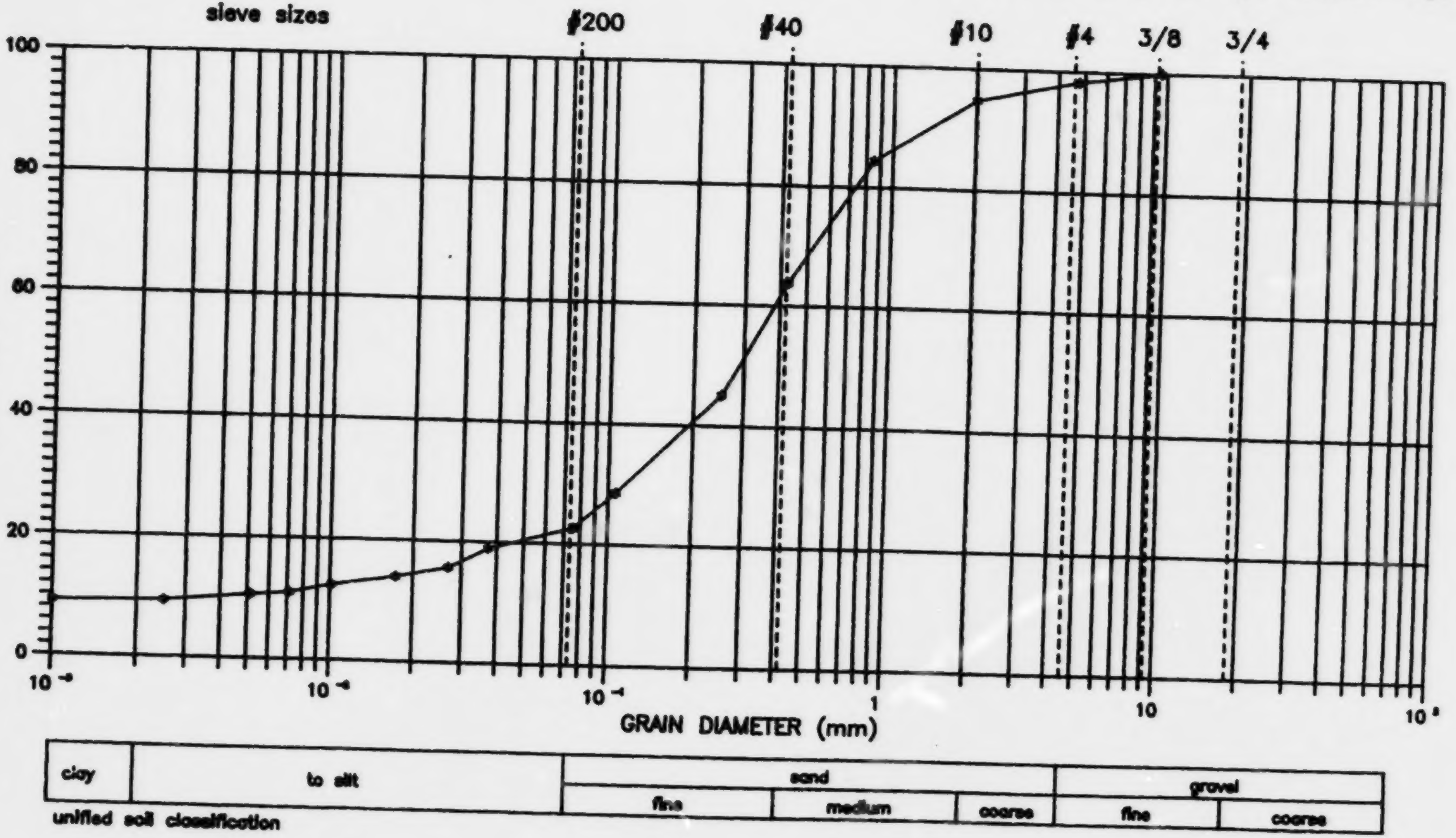


FIGURE C28

GRILLAGE BACKFILL MATERIAL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS -TL REFURBISHMENT-SMITH FALLS,TWR#143,BH-4,S-4.

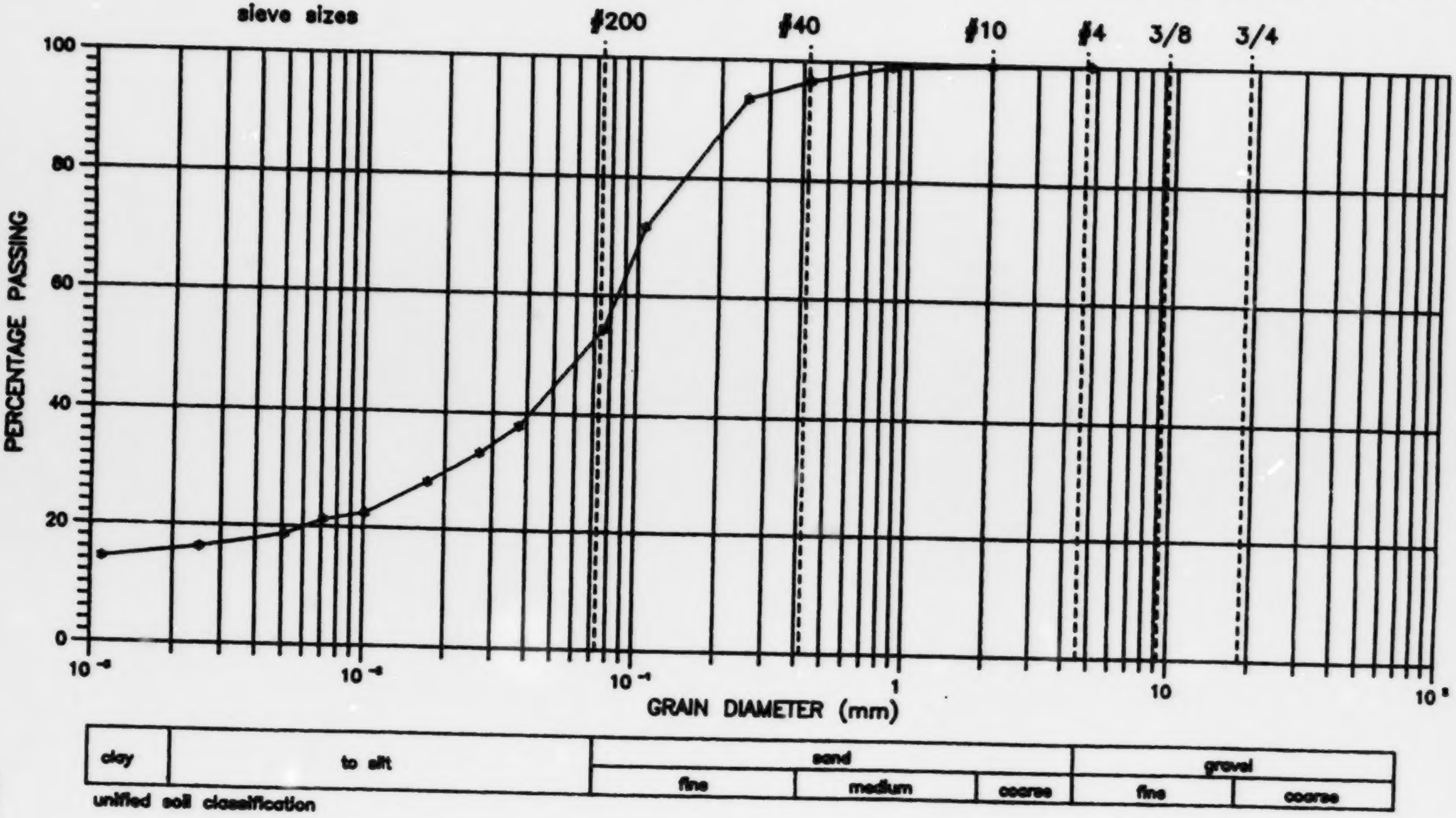


FIGURE C29
GRILLAGE BACKFILL MATERIAL

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS - TL REFURBISHMENT-SMITH FALLS,TWR#143,BH-5,S-2.

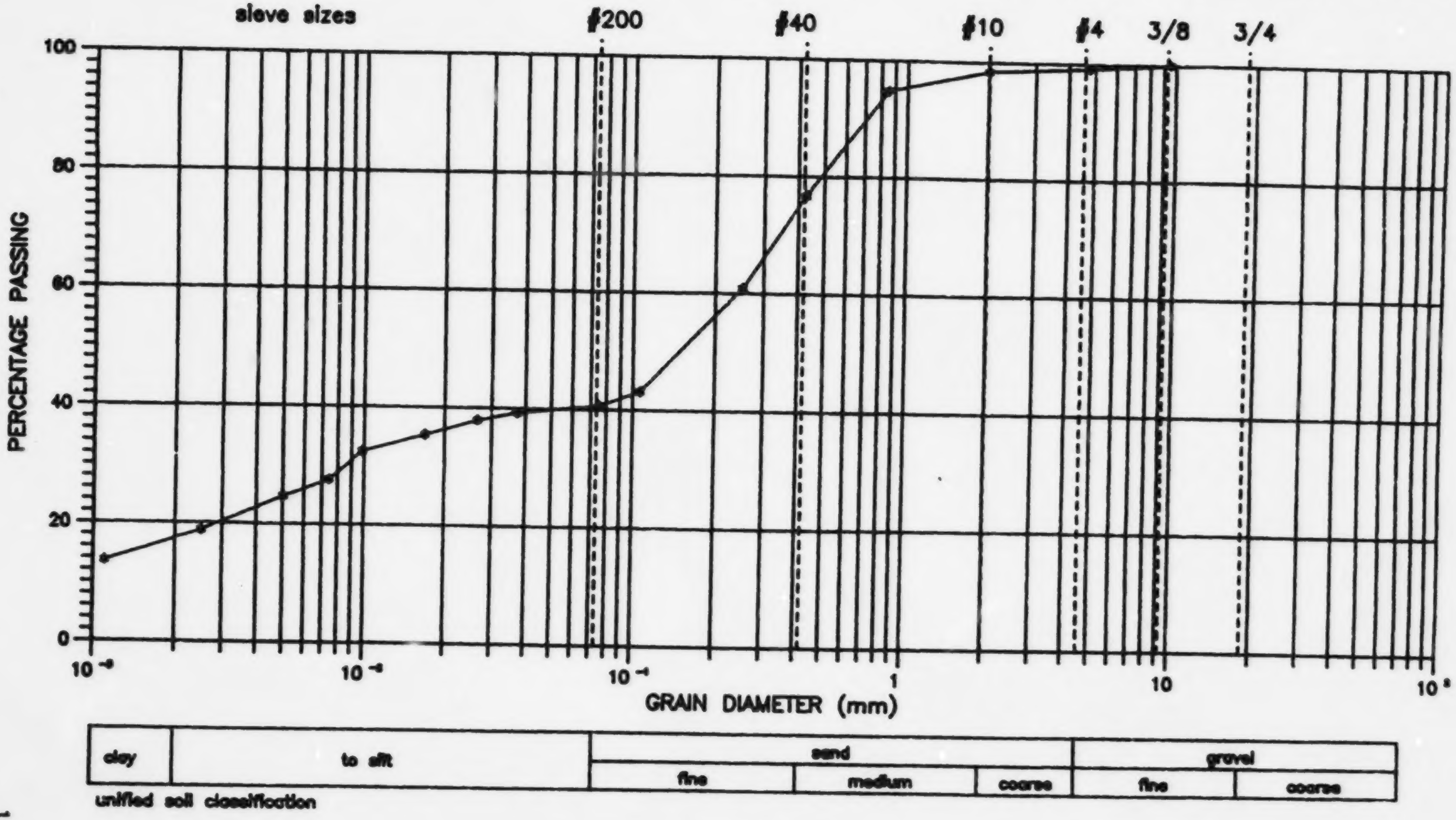


FIGURE C30

GRILLAGE BACKFILL MATERIAL

ONTARIO HYDRO
RESEARCH DIVISION

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ONTARIO HYDRO - CIVIL RESEARCH                                       TEST NO. D-1
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR84-1.DIL

RECORD OF DILATOMETER TEST NO. D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


     LOCATION: TWR # 84 LEG 4 D-1 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
     PERFORMED - DATE:  JAN. 21 1988
                   BY:  Al Morton


     CALIBRATION INFORMATION:
     DELTA A =  .18 BARS   DELTA B   =  .65 BARS   GAGE 0 =  .00 BARS   GWT DEPTH: 8.00 M


     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI        ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST   A     B     ED    ID    KD     U0    GAMMA   SV     PC   OCR    KO    CU   PHI     M     SOIL TYPE
 (M)   (KG)  (BAR) (BAR) (BAR)              (BAR) (T/M3) (BAR)  (BAR)             (BAR) (DEG)  (BAR)
***** ****** ***** ***** ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          .30  2.90   64.  4.75  3.91   .000  1.700   .100    .29  2.85    .69         35.2   108.7     SAND
  .85          .70  3.60   75.  2.80  5.82   .000  1.700   .133    .82  6.18   1.01         32.3   152.6   SILTY SAND
 1.05         2.40 10.20  254.  3.28 13.08   .000  1.900   .171   3.68 21.58   1.75         36.2   599.4   SILTY SAND




END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                              TEST NO. D-2
FILE NAME:      TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:    TWR84-2.DIL

RECORD OF DILATOMETER TEST NO. D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


     LOCATION: TWR # 84 LEG 4 D-2 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
     PERFORMED - DATE:  JAN. 21 1988
                  BY:  Al Morton


     CALIBRATION INFORMATION:
     DELTA A :  .18 BARS   DELTA B    :  .65 BARS   GAGE 0 :  .00 BARS   GWT DEPTH: 8.00 M


     1 BAR : 1.019 KG/CM2 : 1.044 TSF : 14.51 PSI          ANALYSIS USES H20 UNIT WEIGHT :  1.000 T/M3


  Z   THRUST   A     B     ED    ID    KD      U0    GAMMA   SV     PC    OCR    KO    CU   PHI     M       SOIL TYPE
 (M)   (KG)  (BAR) (BAR) (BAR)                 (BAR) (T/M3) (BAR)  (BAR)              (BAR) (DEG)  (BAR)
***** ****** ***** ***** ***** ***** *****   ****** ****** ******  ***** *****  ***** ***** *****  ******  ************

  .80         1.60  8.10  207.  3.98 14.96    .000  1.800   .100   2.49 24.85  1.87        38.4   595.3      SAND
 1.00         2.40 11.00  283.  3.72 15.96    .000  1.900   .137   3.97 28.92  2.02        37.9   833.1      SAND
 1.20         2.90  7.20  126.  1.25 16.84    .000  1.800   .173   8.55 49.55  2.39        30.3   378.4   SANDY SILT
 1.40         3.30 10.30  225.  2.04 15.11    .000  1.900   .210   7.08 33.74  2.11        33.0   649.8   SILTY SAND
 1.60          .70  7.60  221. 11.06  2.37    .000  1.700   .243    .00   .00  -.15        43.0   276.3      SAND



END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                                    TEST NO. D-3
FILE NAME:      TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:    TWR84-3.DIL

RECORD OF DILATOMETER TEST NO. D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


    LOCATION: TWR # 84 LEG 1 D-3 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
    PERFORMED - DATE:  JAN. 21 1988
                  BY:  Al Morton


    CALIBRATION INFORMATION:
    DELTA A :  .18 BARS   DELTA B    :  .65 BARS   GAGE 0 :  .00 BARS   GWT DEPTH: 8.00 M


    1 BAR : 1.019 KG/CM2 : 1.044 TSF : 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT :  1.000 T/M3


  Z   THRUST   A      B     ED    ID    KD     UO    GAMMA   SV     PC   OCR    KO    CU   PHI     M     SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)              (BAR)  (T/M3) (BAR)  (BAR)              (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************


  .65          .90   3.60    68.  1.99  9.86   .000  1.700   .100   1.60 15.95   1.52         31.6   169.5  SILTY SAND
  .85          .70   3.50    72.  2.65  5.86   .000  1.700   .133    .85  6.36   1.03         31.9   145.2  SILTY SAND
 1.05         1.40   4.30    75.  1.47  8.86   .000  1.700   .167   2.42 14.52   1.46         29.5   179.7  SANDY SILT
 1.25          .90   3.30    57.  1.65  5.05   .000  1.600   .198   1.15  5.80   1.02         28.7   105.7  SANDY SILT
 1.45         1.20   3.90    68.  1.53  5.60   .000  1.600   .230   1.57  6.86   1.09         28.6   132.3  SANDY SILT
 1.65          .50   2.30    35.  1.61  2.42   .000  1.600   .261    .61  2.35    .74         27.1    40.3  SANDY SILT




END OF SOUNDING
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            ONTARIO HYDRO - CIVIL RESEARCH                                            TEST NO. D-4
            FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
            FILE NUMBER:   TWR84-4.DIL

            RECORD OF DILATOMETER TEST NO. D-4
            USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
            KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
            MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


                LOCATION: TWR # 84 LEG 2 D-4 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
                PERFORMED - DATE:  JAN. 21 1988
                           BY:  Al Morton


                CALIBRATION INFORMATION:
                DELTA A =  .18 BARS   DELTA B    =  .65 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 8.00 M


                1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST   A      B      ED    ID     KD      U0    GAMMA   SV      PC   OCR     KO     CU   PHI     M      SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)                (BAR)  (T/M3) (BAR)  (BAR)                (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          .70   3.10    57.  2.06  8.01    .000  1.700   .100   1.12 11.16   1.31         31.2   131.2   SILTY SAND
  .85         2.30   6.20   112.  1.39 17.44    .000  1.700   .133   6.82 51.11   2.45         30.9   338.6   SANDY SILT
 1.05         2.50   6.10   101.  1.14 15.24    .000  1.700   .167   3.96 23.77   2.37                292.6      SILT

 1.65         4.90  16.00   374.  2.36 16.57    .000  2.000   .276  10.41 37.78   2.24         34.2  1114.3   SILTY SAND




END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                          TEST NO. D-5
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR84-5.DIL

RECORD OF DILATOMETER TEST NO. D-5
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


     LOCATION: TWR # 84 (10 E OF T)(NATIVE)(#) AUGERED THROUGH FROST 0.3m
     PERFORMED - DATE:  JAN. 21 1988
                  BY:  Al Morton


     CALIBRATION INFORMATION:
     DELTA A =  .18 BARS   DELTA B    =  .65 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 8.00 M


     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI         ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST   A      B      ED    ID    KD     UO    GAMMA   SV     PC    OCR    KO    CU   PHI    M      SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)               (BAR)  (T/M3) (BAR)  (BAR)              (BAR) (DEG)  (BAR)
##### ###### #####  #####  ##### ##### #####  ###### ###### ######  ##### #####  #####  ##### #####  ######  ############


  .65         1.30   4.20    75.  1.58 13.76    .000  1.700   .100   3.12 31.19   2.00         31.1   211.4  SANDY SILT
  .85         1.30   5.40   119.  2.61  9.73    .000  1.800   .135   1.92 14.22   1.45         33.5   234.9  SILTY SAND
 1.05         2.60   8.70   192.  2.20 14.58    .000  1.900   .173   5.31 30.75   2.03         33.4   548.6  SILTY SAND
 1.25         1.50   6.00   134.  2.58  7.20    .000  1.800   .208   1.82  8.75   1.18         32.4   294.9  SILTY SAND
 1.45         2.60  10.30   250.  2.96  9.94    .000  1.900   .245   3.44 14.04   1.44         34.5   624.4  SILTY SAND




END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                                  TEST NO. D-1
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR143-1.DIL

RECORD OF DILATOMETER TEST NO. D-1
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


    LOCATION: TWR # 143 LEG 2 D-1 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
    PERFORMED - DATE:  JAN. 21 1988
                  BY:  Al Morton


    CALIBRATION INFORMATION:
    DELTA A =  .19 BARS   DELTA B    =  .68 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 1.00 M


    1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI        ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B      ED    ID    KD     UO    GAMMA   SV     PC    OCR    KO     CU   PHI      M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)               (BAR)  (T/M3) (BAR)  (BAR)                (BAR) (DEG)  (BAR)
##### ###### ##### ##### ##### ##### #####  ###### ###### ######  ##### #####  #####  ##### #####  ######  ############

  .65          1.00   3.80    70.  1.85 10.93   .000  1.700   .100   1.95 19.52   1.65         31.5   181.7   SILTY SAND
  .85          1.20   4.10    74.  1.65  9.66   .000  1.700   .133   2.17 16.30   1.53         30.4   182.5   SANDY SILT
 1.05          1.00   3.70    67.  1.76  6.84   .005  1.600   .160   1.45  9.04   1.21         29.8   142.7   SANDY SILT
 1.25           .90   3.40    59.  1.74  5.73   .025  1.600   .172   1.18  6.90   1.09         29.3   117.1   SANDY SILT
 1.45           .80   3.10    52.  1.72  4.77   .044  1.600   .183    .97  5.28    .98         28.7    93.5   SANDY SILT
 1.65          1.30   4.20    74.  1.61  6.72   .064  1.700   .197   1.77  8.98   1.21         29.3   156.7   SANDY SILT
 1.85          1.60   7.00   165.  3.21  6.95   .083  1.800   .213   1.63  7.65   1.10         34.0   360.5   SILTY SAND
 2.05          3.40   9.90   205.  1.84 13.91   .103  1.900   .231   6.94 30.09   1.99         32.1   576.9   SILTY SAND
 2.25          2.00   5.30    89.  1.31  7.97   .123  1.700   .244   3.05 12.48   1.37         28.7   201.6   SANDY SILT
 2.45          3.10   7.10   114.  1.10 11.51   .142  1.800   .260   3.98 15.33   2.01                300.3      SILT

END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                               TEST NO. D-2
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR143-2.DIL

RECORD OF DILATOMETER TEST NO. D-2
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

    LOCATION: TWR # 143 LEG 2 D-2 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
    PERFORMED - DATE:  JAN. 21 1988
                  BY:  Al Morton

    CALIBRATION INFORMATION:
    DELTA A =  .19 BARS   DELTA B    =  .68 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 1.00 M

    1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3

  Z   THRUST    A      B     ED    ID    KD      UO    GAMMA   SV      PC    OCR     KO     CU    PHI     M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                  (BAR)  (T/M3) (BAR)   (BAR)                (BAR)  (DEG)  (BAR)
***** ******  *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          1.00   3.70    67.  1.75 10.98    .000  1.600   .100   2.00 20.05   1.67          31.1  172.6  SANDY SILT
  .85           .90   2.90    41.  1.15  7.87    .000  1.600   .131   1.11  8.47   1.58                 93.1     SILT
 1.05           .50   2.40    38.  1.71  4.01    .005  1.600   .158    .66  4.18    .90          28.3   61.2  SANDY SILT
 1.25           .90   3.30    56.  1.62  5.83    .025  1.600   .170   1.22  7.18   1.11          29.0  110.5  SANDY SILT
 1.45          1.00   3.40    56.  1.50  5.89    .044  1.600   .181   1.35  7.43   1.12          28.6  110.9  SANDY SILT
 1.65          1.20   4.50    89.  2.12  6.11    .064  1.800   .197   1.43  7.23   1.10          30.5  181.0  SILTY SAND
 1.85          1.50   5.00    96.  1.87  6.93    .083  1.800   .213   1.93  9.08   1.21          30.2  206.5  SILTY SAND
 2.05          3.60   6.70    81.   .65 15.64    .103  1.800   .229   5.66 24.75   2.41   .658         237.5  CLAYEY SILT
 2.25          3.60   6.30    85.   .69 14.54    .123  1.800   .244   5.39 22.07   2.31   .641         242.3  CLAYEY SILT
 2.45          2.60   5.60    78.   .88  9.85    .142  1.700   .258   3.10 12.03   1.82   .416         192.8  CLAYEY SILT

END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH TEST NO. D-~~2~~3
FILE NAME: TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER: TWR143-3.DIL

RECORD OF DILATOMETER TEST NO. D-~~2~~ D-3
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: TWR # 143 LEG 4 D-3 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
PERFORMED - DATE: JAN. 21 1988
BY: Al Morton

CALIBRATION INFORMATION:
DELTA A = .19 BARS DELTA B = .68 BARS GAGE 0 = .00 BARS GWT DEPTH= 1.00 M

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT = 1.000 T/M3

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  Z   THRUST    A      B      ED    ID     KD      U0    GAMMA    SV      PC   OCR     KO     CU   PHI     M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                 (BAR)  (T/M3)  (BAR)  (BAR)                (BAR) (DEG)  (BAR)
***** ******  *****  *****  ***** ***** *****   ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          1.00   3.00    41.  1.05 11.34    .000  1.600   .100   1.50 14.97   1.99                 107.8      SILT
  .85          1.00   2.60    27.   .66  8.78    .000  1.600   .131   1.32 10.05   1.69   .184           63.0   CLAYEY SILT
 1.05           .90   2.70    34.   .94  6.58    .005  1.600   .158   1.01  6.41   1.40                  70.5      SILT
 1.25           .50   1.90    19.   .87  3.77    .025  1.600   .170    .46  2.68    .94   .082           29.3   CLAYEY SILT
 1.45           .50   2.30    34.  1.63  3.30    .044  1.600   .181    .60  3.30    .83          27.7    48.8   SANDY SILT
 1.65          1.20   4.50    89.  2.12  6.11    .064  1.800   .197   1.43  7.23   1.10          30.5   181.0   SILTY SAND
 1.85          2.80   6.70   110.  1.15 13.06    .083  1.700   .211   3.94 18.68   2.17                 303.9      SILT
 2.05          3.30   9.20   183.  1.68 13.84    .103  1.800   .227   6.98 30.79   2.00          31.5   514.5   SANDY SILT
 2.25          2.60   7.20   136.  1.58 10.32    .123  1.700   .240   4.46 18.55   1.61          30.3   343.8   SANDY SILT
 2.45          2.00   6.00   114.  1.74  7.44    .142  1.700   .254   2.64 10.39   1.28          30.0   253.1   SANDY SILT

END OF SOUNDING
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TEST NO. D-2 (CONTINUED) PAGE 1

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ONTARIO HYDRO - CIVIL RESEARCH                          TEST NO. D-4        TEST NO. D-4
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR143-4.DIL

RECORD OF DILATOMETER TEST NO. D-4
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


    LOCATION: TWR # 143 LEG 4 D-4 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
    PERFORMED - DATE:  JAN. 21 1988
                 BY:  Al Morton


    CALIBRATION INFORMATION:
    DELTA A =  .19 BARS   DELTA B    =  .68 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 1.00 M


    1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B     ED     ID     KD     UO    GAMMA   SV     PC    OCR    KO     CU    PHI     M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                 (BAR)  (T/M3) (BAR)  (BAR)                (BAR)  (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          2.10   6.20   118.  1.59 21.28   .000  1.700   .100   7.10 70.98   2.88          32.2   378.4   SANDY SILT
  .85          2.90   8.50   172.  1.74 21.09   .000  1.800   .135   9.09 67.20   2.84          32.7   552.6   SANDY SILT
 1.05          1.70   4.30    63.  1.01 10.98   .005  1.700   .164   2.33 14.25   1.95                 163.2      SILT
 1.25           .90   3.30    56.  1.62  5.63   .025  1.600   .176   1.20  6.82   1.09          28.9   103.7   SANDY SILT
 1.45          1.50   4.60    81.  1.53  8.11   .044  1.700   .189   2.34 12.37   1.37          29.5   186.7   SANDY SILT
 1.65          1.60   6.00   129.  2.39  7.56   .064  1.800   .205   1.99  9.69   1.23          32.0   288.9   SILTY SAND
 1.85          2.40   8.40   187.  2.39 10.11   .083  1.900   .223   3.48 15.63   1.51          33.0   469.1   SILTY SAND
 2.05          2.00   7.20   158.  2.43  7.85   .103  1.800   .238   2.44 10.23   1.26          32.3   359.8   SILTY SAND
 2.25          1.30   4.30    78.  1.77  5.00   .123  1.700   .252   1.42  5.62   1.01          29.0   143.0   SANDY SILT
 2.45          1.30   5.38   117.  2.84  4.43   .142  1.800   .268   1.13  4.23    .87          31.4   208.8   SILTY SAND

END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                        TEST NO. D-5
FILE NAME:    TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:  TWR143-5.DIL

RECORD OF DILATOMETER TEST NO. D-5
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


     LOCATION: TWR # 143 LEG 3 D-5 (BACKFILL) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
     PERFORMED - DATE:  JAN. 21 1988
                  BY:  Al Morton


     CALIBRATION INFORMATION:
     DELTA A =  .19 BARS   DELTA B    =  .68 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 1.00 M


     1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B     ED    ID    KD     UO    GAMMA   SV      PC   OCR     KO    CU   PHI     M      SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)              (BAR)  (T/M3) (BAR)   (BAR)              (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          3.50   7.90   129.  1.05 35.13   .000  1.800   .100   8.74 87.45   3.80               474.6      SILT
  .85          4.00   9.90   183.  1.34 29.10   .000  1.800   .135  19.19 *****   3.82         31.9  643.5   SANDY SILT
 1.05           .70   3.10    56.  1.99  4.94   .005  1.700   .164    .88  5.38    .98         29.6  102.6   SILTY SAND
 1.25          1.60   6.00   129.  2.33  8.85   .025  1.800   .179   2.27 12.62   1.38         32.4  307.2   SILTY SAND
 1.45          1.60   5.10    96.  1.71  8.35   .044  1.700   .193   2.44 12.61   1.38         30.2  223.1   SANDY SILT
 1.65          1.40   4.30    74.  1.50  6.88   .064  1.700   .207   1.97  9.50   1.23         29.0  158.2   SANDY SILT
 1.85          1.80   8.00   194.  3.41  7.37   .083  1.800   .223   1.82  8.16   1.12         34.7  433.9      SAND
 2.05          1.60   5.70   118.  2.22  6.40   .103  1.800   .238   1.82  7.65   1.12         31.0  245.3   SILTY SAND
 2.25          1.90   5.10    85.  1.32  7.34   .123  1.700   .252   2.74 10.86   1.30         28.5  186.6   SANDY SILT
 2.45          1.70   4.40    67.  1.16  6.23   .142  1.700   .266   1.56  5.89   1.35               135.5      SILT

END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH TEST NO. D-6
FILE NAME: TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER: TWR143-6.DIL

RECORD OF DILATOMETER TEST NO. D-6
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)

LOCATION: TWR # 143 LEG 3 D-6 (~~native~~ Backfill) GRILLAGE (*) AUGERED THROUGH FROST 0.3 m
PERFORMED - DATE: JAN. 21 1988
BY: Al Morton

CALIBRATION INFORMATION:
DELTA A = .19 BARS DELTA B = .68 BARS GAGE 0 = .00 BARS GWT DEPTH= 1.00 M

1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI ANALYSIS USES H2O UNIT WEIGHT : 1.000 T/M3

```
  Z   THRUST   A     B     ED    ID    KD     U0   GAMMA   SV     PC   OCR    KO    CU   PHI     M      SOIL TYPE
 (M)   (KG)  (BAR) (BAR) (BAR)              (BAR) (T/M3) (BAR)  (BAR)             (BAR) (DEG)  (BAR)
***** ****** ***** ***** ***** ***** ***** ****** ****** ****** ***** *****  ***** ***** ***** ******  ************

  .65         1.20  3.90   67.  1.48 12.98   .000  1.600   .100   2.86 28.63  1.92        30.5  183.2  SANDY SILT
  .85          .90  2.90   41.  1.15  7.87   .000  1.600   .131   1.11  8.47  1.58               93.1     SILT
 1.05 *        .00   .00  -30. -4.70         .005  P01 =   .23  P0 =    .19  P1 :  -.68                 QUESTIONABLE
 1.25          .50  2.00   23.  1.04  3.74   .025  1.600   .170    .45  2.65   .34               34.9     SILT
 1.45          .70  2.50   34.  1.22  4.41   .044  1.600   .181    .91  5.03   .98        27.2   57.4  SANDY SILT
 1.65         1.50  4.20   67.  1.25  7.86   .064  1.700   .195   2.41 12.34  1.36        28.4  150.9  SANDY SILT
 1.85         1.60  6.90  161.  3.13  7.04   .083  1.800   .211   1.66  7.88  1.11        33.9  354.3  SILTY SAND
 2.05         1.90  5.50   99.  1.55  8.24   .103  1.700   .225   2.34 12.66  1.38        29.6  230.1  SANDY SILT
 2.25         1.60  4.70   81.  1.50  6.53   .123  1.700   .238   2.08  8.71  1.19        28.9  169.6  SANDY SILT
 2.45         1.40  2.70   16.   .32  5.70   .142  1.600   .250   1.28  5.13  1.27  .204         30.1     CLAY
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END OF SOUNDING

(*) missed readings due to obstruction

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ONTARIO HYDRO - CIVIL RESEARCH                                               TEST NO. D-7
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR143-7.DIL

RECORD OF DILATOMETER TEST NO. D-7
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


   LOCATION: TWR # 143 (3 m W OF T)(NATIVE)(*)AUGERED THROUGH FROST 0.3m
   PERFORMED - DATE:  JAN. 21 1988
                 BY:  Al Morton


   CALIBRATION INFORMATION:
   DELTA A =  .19 BARS   DELTA B    =  .68 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 1.00 M


   1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST    A      B      ED    ID    KD     UO    GAMMA   SV     PC    OCR     KO     CU    PHI      M       SOIL TYPE
 (M)   (KG)   (BAR)  (BAR)  (BAR)                  (BAR)  (T/M3) (BAR)  (BAR)                (BAR)  (DEG)   (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  *****  ***** *****  ******  ************

  .65          4.20   9.50   161.  1.12 41.68   .000  1.800   .100  11.42 *****   4.17                 621.7      SILT
  .85          9.20  16.00   216.   .68 65.76   .000  1.950   .138  32.15 *****   5.31  2.395          925.4   CLAYEY SILT
 1.05          6.30  11.70   165.   .76 36.46   .005  1.950   .172  15.90 92.66   3.88  1.423          614.8   CLAYEY SILT
 1.25          2.60   8.20   172.  1.96 13.36   .025  1.900   .189   5.18 27.36   1.92         32.4    478.1   SILTY SAND
 1.45          3.70  11.20   242.  1.98 16.98   .044  1.900   .207   8.77 42.36   2.33         33.1    725.0   SILTY SAND
 1.65          3.80   9.50   176.  1.38 16.55   .064  1.800   .223  10.31 46.30   2.35         30.8    523.9   SANDY SILT
 1.85          6.70  16.00   307.  1.39 26.46   .083  1.950   .241  27.87 *****   3.51         31.9   1050.8   SANDY SILT
 2.05          3.50  10.20   212.  1.86 12.72   .103  1.900   .259   6.62 25.55   1.86         31.9    579.5   SILTY SAND
 2.25          1.70   5.10    92.  1.62  6.02   .123  1.700   .273   2.06  7.55   1.13         29.0    185.6   SANDY SILT
 2.45          1.30   4.20    74.  1.71  4.38   .142  1.600   .284   1.34  4.70    .94         28.5    126.7   SANDY SILT
 2.65          1.00   2.50    23.   .66  3.36   .162  1.600   .296    .67  2.25    .86   .125           31.9   CLAYEY SILT

END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                          TEST NO. D-8
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR143-8.DIL

RECORD OF DILATOMETER TEST NO. D-8
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


    LOCATION: TWR # 143 (10 W OF T)(NATIVE)(*) AUGERED THROUGH FROST 0.3m
    PERFORMED - DATE:  JAN. 21 1988
                 BY:  Al Morton


    CALIBRATION INFORMATION:
    DELTA A =  .19 BARS   DELTA B    =  .68 BARS   GAGE 0 =  .00 BARS   GWT DEPTH= 1.00 M


    1 BAR = 1.019 KG/CM2 = 1.044 TSF = 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT =  1.000 T/M3


  Z   THRUST   A      B     ED    ID    KD      U0   GAMMA    SV     PC    OCR     KO    CU   PHI      M      SOIL TYPE
 (M)   (KG)  (BAR)  (BAR)  (BAR)               (BAR) (T/M3)  (BAR)  (BAR)               (BAR) (DEG)  (BAR)
***** ****** *****  *****  ***** ***** *****  ****** ****** ******  ***** *****  ***** ***** *****  ******  ************

  .65         3.40   7.90   132.  1.12 34.08    .000  1.800   .100   8.34 83.40   3.74               484.2      SILT
  .85         4.90  10.20   161.   .96 35.98    .000  1.800   .135  12.28 90.73   3.85               599.2      SILT
 1.05         5.90  11.00   154.   .76 35.44    .005  1.800   .166  14.69 88.62   3.82 1.326         569.3  CLAYEY SILT
 1.25         3.70   9.70   187.  1.49 19.89    .025  1.800   .181  11.60 63.94   2.72        31.7   589.0  SANDY SILT
 1.45         2.80   8.00   158.  1.67 13.84    .044  1.800   .197   6.10 30.94   2.00        31.4   443.0  SANDY SILT
 1.65         2.90   7.70   143.  1.46 13.29    .064  1.800   .213   6.40 30.05   1.96        30.6   396.6  SANDY SILT
 1.85         3.90  10.10   194.  1.50 16.36    .083  1.800   .229  10.05 43.95   2.31        31.2   576.0  SANDY SILT
 2.05         2.90   7.70   143.  1.48 11.42    .103  1.800   .244   5.54 22.68   1.75        30.2   376.0  SANDY SILT
 2.25         1.30   3.70    56.  1.24  5.04    .123  1.600   .256   1.56  6.08   1.05        27.5   101.8  SANDY SILT
 2.45         1.00   2.40    19.   .54  3.81    .142  1.600   .268    .73  2.74    .95  .132          29.2  SILTY CLAY

END OF SOUNDING
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ONTARIO HYDRO - CIVIL RESEARCH                                          TEST NO. D-9
FILE NAME:     TL REFURBISHMENT - SMITH FALLS GEOTECHNICAL INVESTIGATION
FILE NUMBER:   TWR143-9.DIL

RECORD OF DILATOMETER TEST NO. D-9
USING DATA REDUCTION PROCEDURES IN MARCHETTI (ASCE,J-GED,MARCH 80)
KO IN SANDS DETERMINED USING SCHMERTMANN METHOD (1983)
MODIFIED MAYNE AND KULHAWY FORMULA USED FOR OCR IN SANDS (ASCE,J-GED,JUNE 82)


     LOCATION: TWR # 143 (10 FT W OF T)(NATIVE)(*) AUGERED THROUGH FROST 0.3m
     PERFORMED - DATE:  JAN. 21 1988
                   BY:  Al Morton


     CALIBRATION INFORMATION:
     DELTA A :  .19 BARS   DELTA B    :  .68 BARS   GAGE 0 :  .00 BARS   GWT DEPTH: 1.00 M


     1 BAR : 1.019 KG/CM2 : 1.044 TSF : 14.51 PSI          ANALYSIS USES H2O UNIT WEIGHT :  1.000 T/M3


  Z   THRUST   A      B     ED    ID    KD     UO    GAMMA   SV     PC   OCR    KO    CU   PHI     M      SOIL TYPE
 (M)   (KG)  (BAR)  (BAR) (BAR)               (BAR)  (T/M3) (BAR)  (BAR)             (BAR) (DEG)  (BAR)
***** ****** *****  ***** ***** ***** *****  ****** ****** ******  ***** *****  ***** ***** *****  ******  ************

  .65         5.00  13.10  263.  1.57 48.28   .000  1.950   .100  36.22 *****  6.07        33.6  1051.3  SANDY SILT
  .85         8.00  14.20  194.   .71 57.30   .000  1.950   .138  25.94 *****  4.94  2.016         806.5  CLAYEY SILT
 1.05         5.30  11.20  183.  1.01 31.02   .005  1.800   .169  12.15 72.02  3.55                654.6     SILT
 1.25         2.50   7.90  165.  1.95 13.09   .025  1.900   .186   4.92 26.43  1.89        32.3   454.7  SILTY SAND
 1.45         2.70   7.10  129.  1.39 13.21   .044  1.800   .202   6.10 30.19  1.96        30.3   355.4  SANDY SILT
 1.65         2.10   7.10  150.  2.15  9.27   .064  1.800   .218   3.05 14.02  1.44        31.9   365.7  SILTY SAND
 1.85         3.10   8.90  180.  1.75 12.68   .083  1.800   .233   6.05 25.91  1.86        31.5   489.4  SANDY SILT
 2.05         1.60   2.50    1.   .02  6.93   .103  1.500   .243   1.69  6.95  1.45   .253           2.3     MUD
 2.25         1.10   2.60   23.   .58  4.45   .123  1.600   .255    .89  3.49  1.07   .153          38.4  SILTY CLAY
 2.45          .90   2.00    8.   .26  3.53   .142  1.500   .265    .64  2.43   .90   .119          12.0     MUD
 2.65          .70   2.50   34.  1.43  2.46   .162  1.600   .277    .67  2.44   .76         26.7    38.6  SANDY SILT
 2.85         1.30   4.30   78.  1.86  4.14   .182  1.700   .290   1.25  4.29   .91         28.8   129.5  SILTY SAND
 3.05         1.00   3.00   41.  1.27  3.09   .201  1.600   .302    .96  3.17   .83         26.6    55.4  SANDY SILT

END OF SOUNDING
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TABLE C1

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 84 LEG # 1 GRILLAGE BACKFILL MATERIAL

DEPTH	DILATOMETER DATA (D-3) *				SPT (BH-5)		DYNAMIC CONE (C-3)		LABORATORY SOIL DESCRIPTION
(m)	Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	N-VALUES	Ø (deg)	BLOWS/FT	Ø (deg)	
0.00									MOIST LOOSE SILTY SAND FROM 0.00 m TO 1.8 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-5
0.1									
0.2									
0.3					5	< 28	16	< 28	
0.4									
0.5									
0.6							4	< 28	STIFF SILTY CLAY FROM 0.00 m TO 2.0 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-6
0.7	1.52	-	32	SILTY SAND					
0.8									
0.9	1.03	-	32	SILTY SAND	7	< 28	4	< 28	
1									
1.1	1.46	-	30	SANDY SILT					
1.2							3	< 28	
1.3	1.02	-	29	SANDY SILT					
1.4									
1.5	1.09	-	29	SANDY SILT	5	< 28	4	< 28	
1.6									
1.7	0.74	-	27	SANDY SILT					
1.8							2	< 28	
1.9							REFUSAL		
2									
		AVERAGE	30			< 28		< 28	

NOTE (*) AUGERED THROUGH 0.3m OF FROST

TABLE C2

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 84 LEG # 2 GRILLAGE BACKFILL MATERIAL

DEPTH	DILATOMETER DATA (D-4) *				SPT (BH-8)		DYNAMIC CONE (C-5)		LABORATORY SOIL DESCRIPTION
(m)	Ko	Cu (kPa)	Ø' (deg)	SOIL TYPE	N-VALUES	Ø' (deg)	BLOWS/FT	Ø' (deg)	
0.00									
0.1									MOIST VERY LOOSE SILTY SAND FROM 0.00 m TO 2.0 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-8
0.2									
0.3					3	< 28	2	< 28	
0.4									
0.5									
0.6							1	< 28	COMPACT SILTY CLAY FROM 0.00 m TO 2.0 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-9
0.7	1.31	-	31	SILTY SAND					
0.8									
0.9	2.45	-	31	SILTY SAND	(+)	(+)	3	< 28	
1									
1.1	2.37	-	-	SILT					
1.2							3	< 28	
1.3									
1.4	(AUGERED FROM 1.2 m TO 1.6 m)								
1.5					3	< 28	2	< 28	
1.6									
1.7	2.24	-	34	SILTY SAND					
1.8							2	< 28	
1.9									
2							REFUSAL		
	AVERAGE		32			< 28		< 28	

NOTE (*) AUGERED THROUGH 0.3m OF FROST
(+) AUGERED THROUGH SILTY SAND WITH COBBLES AND BOULDERS TO 1.5 m

TABLE C3

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 84 LEG # 4 GRILLAGE BACKFILL MATERIAL

DEPTH (m)	DILATOMETER DATA (D-1) * Ko	Cu (kPa)	Ø'(deg)	SOIL TYPE	DILATOMETER DATA (D-2) * Ko	Cu (kPa)	Ø'(deg)	SOIL TYPE	SPT (BH-1) N-VALUES	Ø'(deg)	DYNAMIC CONE (C-1) BLOWS/FT	Ø'(deg)	LABORATORY SOIL DESCRIPTION
0.00													
0.1													MOIST LOOSE SILTY SAND FROM 0.00 m TO 1.8 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-1
0.2													
0.3													
0.4									8	< 28	16	< 28	
0.5													
0.6													
0.7	0.69	-	35	SAND							5	< 28	MOIST COMPACT SILTY SAND FROM 0.00 m TO 1.8 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-2
0.8					1.87	-	38	SAND					
0.9	1.01	-	32	SILTY SAND									
1									5	< 28	8	< 28	
1.1	1.75	-	36	SILTY SAND	2.02	-	38	SAND					
1.2					2.39	-	30	SANDY SILT					
1.3											2	< 28	
1.4					2.11	-	33	SILTY SAND					
1.5													
1.6					-	-	43	SAND	8	< 28	3	< 28	
1.7													
1.8													
1.9											2	< 28	
2											REFUSAL		
		AVERAGE	34							< 28		< 28	

NOTE (*) AUGERED THROUGH 0.3m OF FROST

TABLE C4

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 84 LEG # 1 NATIVE MATERIAL

DEPTH	DILATOMETER DATA (D-5) #				SPT (BH-7)		DYNAMIC CONE (C-4)		LABORATORY SOIL DESCRIPTION
(m)	Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	N-VALUES	Ø (deg)	BLOWS/FT	Ø (deg)	
0.00									MOIST COMPACT SAND FROM 0.00 m TO 1.8 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-7
0.1									
0.2									
0.3					(+)	(+)	(++)	(++)	
0.4									
0.5									
0.6									
0.7	2	-	31	SANDY SILT					
0.8									
0.9	1.45	-	34	SILTY SAND			5	< 28	
1					34				
1.1	2.03	-	33	SILTY SAND					
1.2							6	< 28	
1.3	1.18	-	32	SILTY SAND					
1.4									
1.5	1.44	-	35	SILTY SAND			14	< 28	
1.6									
1.7									
1.8					REFUSAL		12	< 28	
1.9							REFUSAL		
2									
		AVERAGE	33		34			< 28	

NOTE (#) AUGERED THROUGH 0.3m OF FROST
(+) AUGERED THROUGH FROST AND COBBLES TO 0.75 m

TABLE C5

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 84 LEG # 2 NATIVE MATERIAL

DEPTH	DILATOMETER DATA *				SPT (BH-10)		DYNAMIC CONE (C-6)		
(m)	Ko	Cu (kPa)	ϕ' (deg)	SOIL TYPE	N-VALUES	ϕ' (deg)	BLOWS/FT	ϕ' (deg)	LABORATORY SOIL DESCRIPTION
0.00									
0.1									MOIST LOOSE TO DENSE SILTY SAND FROM 0.00 m TO 1.8 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-10
0.2									
0.3					5	< 28	24	31	
0.4									
0.5									
0.6							6	< 28	
0.7									
0.8									
0.9					11	29	3	< 28	
1									
1.1									
1.2							6	< 28	
1.3									
1.4									
1.5							12	< 28	
1.6									
1.7									
1.8					REFUSAL		15	< 28	
1.9							REFUSAL		
2									
					AVERAGE	28		<28	

NOTE (*) DILATOMETER TEST NOT PERFORMED IN NATIVE SOIL AT TOWER #84 LEG #2

TABLE C6

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 84 LEG # 4 NATIVE MATERIAL

DEPTH (m)	DILATOMETER DATA * Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	SPT (BH-3) N-VALUES	Ø (deg)	DYNAMIC CONE (C-2) BLOWS/FT	Ø (deg)	LABORATORY SOIL DESCRIPTION
0.00									
0.1									MOIST COMPACT SAND FROM 0.00 m TO 1.8 m OCCASSIONAL COBBLES AND BOULDERS FOR BH-3
0.2									
0.3					15	32	34	33	
0.4									
0.5									
0.6							26	31	
0.7									
0.8									
0.9					16	33	74	(+)	
1									
1.1									
1.2									
1.3									
1.4									
1.5					26	35			
1.6									
1.7									
1.8							REFUSAL		
1.9									
2									
					AVERAGE	34		32	

NOTE (*) DILATOMETER TEST NOT PERFORMED IN NATIVE SOIL AT TOWER #84 LEG #4
(+) POSSIBLY HIT COBBLE OR BOULDER

TABLE C7

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 143 LEG # 2 GRILLAGE BACKFILL MATERIAL

DEPTH (m)	DILATOMETER DATA (D-1) *				DILATOMETER DATA (D-2) *				SPT (BH-7)		DYNAMIC CONE (C-5)		LABORATORY SOIL DESCRIPTION
	Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	N-VALUES	Ø (deg)	BLOWS/FT	Ø (deg)	
0.00													COMPACT SILTY CLAY WITH ORGANI
0.1													FROM 0.00 m TO 1.2 m
0.2													AND MOIST SAND
0.3									7	< 28	4	< 28	FROM 1.2 m TO 2.4 m FOR BH-7
0.4													
0.5													
0.6											3	< 28	STIFF CLAY
0.7	1.65	-	32	SILTY SAND	1.67	-	31	SANDY SILT					FROM 0.00 m TO 1.2 m
0.8													AND MOIST SAND
0.9	1.53	-	30	SANDY SILT	1.58	-	-	SILT	4	< 28	5	< 28	FROM 1.2 m TO 1.8 m FOR BH-8
1													
1.1	1.21	-	30	SANDY SILT	0.9	-	28	SANDY SILT					
1.2											6	< 28	
1.3	1.09	-	29	SANDY SILT	1.11	-	29	SANDY SILT					
1.4													
1.5	0.98	-	29	SANDY SILT	1.12	-	29	SANDY SILT	8	< 28	8	< 28	
1.6													
1.7	1.21	-	29	SANDY SILT	1.1	-	31	SILTY SAND					
1.8											3	< 28	
1.9	1.1	-	34	SILTY SAND	1.21	-	30	SILTY SAND					
2													
2.1	1.99	-	32	SILTY SAND	2.41	65.8	-	CLAYEY SILT	20	33	16	< 28	
2.2													
2.3	1.37	-	29	SANDY SILT	2.31	64.1	-	CLAYEY SILT					
2.4											16	< 28	
2.5	2.01	-	-	SILT	1.82	41.6	-	CLAYEY SILT					
2.6													
2.7													
2.8													
2.9													
3													
	AVERAGE		29				29			< 28		< 28	

NOTE (*) AUGERED THROUGH 0.3m OF FROST

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 143 LEG # 3 GRILLAGE BACKFILL MATERIAL

DEPTH	DILATOMETER DATA (D-5) *				DILATOMETER DATA (D-6) *				SPT (BH-2)		DYNAMIC CONE (C-1)		LABORATORY SOIL DESCRIPTION
(m)	Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	Ko	Cu (kPa)	Ø (deg)	SOIL TYPE	N-VALUES	Ø (deg)	BLOWS/FT	Ø (deg)	
0.00													LOOSE SILTY SAND
0.1													FROM 0.00 m TO 1.2 m
0.2													AND VERY LOOSE SILTY SAND
0.3									8	< 28	5	< 28	FROM 1.2 m TO 2.4 m FOR BH-2
0.4													
0.5													
0.6											5	< 28	FIRM SILTY CLAY
0.7	3.8	-	-	SILT	1.92	-	31	SANDY SILT					FROM 0.00 m TO 1.0 m
0.8													AND MOIST SAND
0.9	3.82	-	32	SANDY SILT	1.58	-	-	SILT	8	< 28	4	< 28	FROM 1.0 m TO 1.6 m
1													AND NATIVE STIFF CLAY
1.1	0.98	-	30	SILTY SAND	-	-	-	QUESTIONABLE					FROM 1.6 m TO 2.3 m FOR BH-1
1.2											3	< 28	
1.3	1.38	-	32	SILTY SAND	0.94	-	-	SILT					
1.4													
1.5	1.38	-	30	SANDY SILT	0.98	-	27	SANDY SILT	3	< 28	4	< 28	
1.6													
1.7	1.23	-	29	SANDY SILT	1.36	-	28	SANDY SILT					
1.8											6	< 28	
1.9	1.12	-	35	SAND	1.11	-	34	SILTY SAND					
2													
2.1	1.12	-	31	SILTY SAND	1.38	-	30	SANDY SILT	3	< 28	7	< 28	
2.2													
2.3	1.3	-	29	SANDY SILT	1.19	-	29	SANDY SILT					
2.4											8	< 28	
2.5	1.35	-	-	SILT	1.27	20.4	-	CLAY					
2.6													
2.7													
2.8													
2.9													
3													
		AVERAGE	30-31				31			< 28		< 28	

NOTE (*) AUGERED THROUGH 0.3m OF FROST

TABLE C9

COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 143 LEG # 4 GRILLAGE BACKFILL MATERIAL

DEPTH	DILATOMETER DATA (D-3) *				DILATOMETER DATA (D-4) *				SPT (BH-4)		DYNAMIC CONE (C-3)		LABORATORY SOIL DESCRIPTION
(m)	Ko	Cu (kPa)	Ø' (deg)	SOIL TYPE	Ko	Cu (kPa)	Ø' (deg)	SOIL TYPE	N-VALUES	Ø' (deg)	BLOWS/FT	Ø' (deg)	
0.00													COMPACT SILTY CLAY
0.1													FROM 0.00 m TO 1.1 m
0.2													AND MOIST SAND
0.3									6	< 28	5	< 28	FROM 1.1 m TO 2.4 m FOR BH-4
0.4													
0.5													
0.6											1	< 28	SILTY CLAY
0.7	1.99	-	-	SILT	2.88	-	32	SANDY SILT					FROM 0.00 m TO 0.6 m
0.8													AND MOIST SAND
0.9	1.69	18.4	-	CLAYEY SILT	2.84	-	33	SANDY SILT	11	30	2	< 28	FROM 0.6 m TO 2.4 m FOR BH-5
1													
1.1	1.4	-	-	SILT	1.95	-	-	SILT					
1.2											2	< 28	
1.3	0.94	8.2	-	CLAYEY SILT	1.09	-	29	SANDY SILT					
1.4													
1.5	0.83	-	28	SANDY SILT	1.37	-	30	SANDY SILT	7	< 28	3	< 28	
1.6													
1.7	1.1	-	31	SILTY SAND	1.23	-	32	SILTY SAND					
1.8											3	< 28	
1.9	2.17	-	-	SILT	1.51	-	33	SILTY SAND					
2													
2.1	2	-	32	SANDY SILT	1.26	-	32	SILTY SAND	7	< 28	6	< 28	
2.2													
2.3	1.61	-	30	SANDY SILT	1.01	-	29	SANDY SILT					
2.4											9	< 28	
2.5	1.28	-	30	SANDY SILT	0.87	-	31	SILTY SAND					
2.6													
2.7													
2.8													
2.9													
3													
		AVERAGE	31				31			28		28	

NOTE (*) AUGERED THROUGH 0.3m OF FROST

TABLE C10
COMPARISON OF SOIL STRENGTH PROPERTIES
TL REFURBISHMENT - SMITH FALLS
TOWER # 143 NATIVE MATERIAL

DEPTH	DILATOMETER DATA (D-7) *			SOIL TYPE	DILATOMETER DATA (D-8) *			SOIL TYPE	DILATOMETER DATA (D-9) *			SOIL TYPE	SPT (BH-3) (+)		SPT (BH-6) (++)		SPT (BH-9) (+++)		DYNAMIC CONE (C-2 *)		DYNAMIC CONE (C-4 *)		DYNAMIC CONE (C-6 *)		LABORATORY SOIL DESCRIPTION
(m)	Ko	Cu (kPa)	Ø (deg)		Ko	Cu (kPa)	Ø (deg)		Ko	Cu (kPa)	Ø (deg)		N-VALUES	Ø (deg)	N-VALUES	Ø (deg)	N-VALUES	Ø (deg)	BLOWS/FT	Ø (deg)	BLOWS/FT	Ø (deg)	BLOWS/FT	Ø (deg)	
0.00																									MOIST COMPACT SILTY SAND FROM 0.00 m TO 1.8 m AND COMPACT SAND FROM 1.8 m TO 2.4 m FOR BH-3
0.1																									
0.2																									
0.3													12	31	6	< 28	15	32	5	< 28	28	31	9	< 28	
0.4																									
0.5																									
0.6																			3	< 28	9	< 28	6	< 28	MOIST COMPACT SILTY SAND FROM 0.00 m TO 1.2 m AND COMPACT SAND FROM 1.2 m TO 2.4 m FOR BH-6
0.7	4.17	-	-	SILT	2.74	-	-	SILT	6.07	-	34	SANDY SILT													
0.8																									
0.9	5.31	239.5	-	CLAYEY SILT	3.05	-	-	SILT	4.94	201.6	-	CLAYEY SILT	22	34	23	34	17	33	4	< 28	12	< 28	9	< 28	
1																									
1.1	3.08	142.3	-	CLAYEY SILT	3.82	132.6	-	CLAYEY SILT	3.58	-	-	SILT													
1.2																			3	< 28	12	< 28	11	< 28	MOIST COMPACT SILTY SAND FROM 0.00 m TO 1.2 m AND COMPACT SAND FROM 1.2 m TO 2.4 m FOR BH-9
1.3	1.52	-	33	SILTY SAND	2.72	-	30	SANDY SILT	1.89	-	32	SILTY SAND													
1.4																									
1.5	2.33	-	33	SILTY SAND	2	-	31	SANDY SILT	1.96	-	30	SANDY SILT	10	29	14	32	20	33	4	< 28	12	< 28	14	< 28	
1.6																									
1.7	2.38	-	31	SANDY SILT	1.96	-	31	SANDY SILT	1.44	-	32	SILTY SAND													
1.8																			6	< 28	12	< 28	6	< 28	
1.9	2.51	-	32	SANDY SILT	2.31	-	31	SANDY SILT	1.66	-	32	SANDY SILT													
2																									
2.1	1.86	-	33	SILTY SAND	1.75	-	30	SANDY SILT	1.45	25.3	-	MUD	8	< 28	5	< 28	14	32	7	< 28	16	< 28	17	< 28	
2.2																									
2.3	1.13	-	29	SANDY SILT	1.08	-	28	SANDY SILT	1.07	15.3	-	SILTY CLAY													
2.4																			8	< 28	18	< 28	21	30	
2.5	0.94	-	29	SANDY SILT	0.98	13.2	-	SILTY CLAY	0.9	11.9	-	MUD													
2.6																									
2.7	0.86	12.5	-	CLAYEY SILT					0.75	-	27	SANDY SILT											13	< 28	
2.8																									
2.9									0.91	-	29	SILTY SAND													
3									0.83	-	27	SANDY SILT													
		average	31				31				31			30		31		32		< 28		< 28		< 28	

NOTE (*) PUSHED THROUGH 0.3m OF FROST
(+) BH-3 NEAR TOWER 0143 LOG 03 IN NATIVE SOIL
(++) BH-6 NEAR TOWER 0143 LOG 04 IN NATIVE SOIL
(+++) BH-9 NEAR TOWER 0143 LOG 02 IN NATIVE SOIL

APPENDIX D

ROCK ANCHOR AND GRILLAGE TESTS TL REFURBISHMENT PROGRAM

G. SENKIW, MECHANICAL RESEARCH
REPORT NO BG88-18-H

91602
new 82-10

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FOR [illegible] ONLY
Unless [illegible] authorized
by a [illegible]

Rock Anchor and Grillage Tests
Transmission Line Refurbishment Program

INTRODUCTION

A test program consisting of uplift and lateral tests on earth grillages and uplift tests on paired rock anchors was completed. These tests, summarized in Tables 1 and 2, formed an integral part of an assessment of existing 115kV, single circuit, Kingston type transmission towers for the Transmission Line Refurbishment program. Records show that these towers were built in 1924. The earth grillages of Towers 143 and 84 as well as the rock anchors of Towers 145 and 151 of the S1K circuit became available when a temporary by-pass line was constructed. Figure 1 shows the geographic location of these towers while Figure 2 depicts the orientation of the tower legs and the location of the individual rock anchors. The tests commenced on February 1 and were completed on February 10,1988.

Description of the Earth Grillages and Rock Anchors

The construction details of the earth grillages are shown in Figure 3. Figure 4 depicts the earth grillage when it was dug up after completing the uplift test. Prior to the pullout or lateral tests only the protruding 3" angle was visible. The grillages at Towers 143 and 84 had been installed 1.83m and 1.52m deep respectively.

The paired rock anchors consisted of 1" wedge type rock bolts spaced approximately 0.45m apart. The projecting 100 to 150mm length was threaded with 8 tpi. An inspection of the rock anchors after the tests revealed that they had been installed to depth of 1.22m.

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TEST ARRANGEMENTS AND TEST PROCEDURES

i) Uplift Tests on Earth Grillages

Appendix I describes the general test arrangements and test procedures that are used for testing grillages, footings, H-piles and single rock anchors. Figures 5 to 8 inclusive depict the actual test arrangement that was used for testing the earth grillages for Towers 143 and 84. The locations of the soil/rock uplift measuring rod indicators or "tell-tales" are shown in Figures 9 to 12.

The 1 3/4" diameter pulling rod was threaded into a threaded steel plate adaptor which was bolted to the projecting grillage angle. A pair of 530 kN (60 ton) capacity hydraulic jacks were used to apply the uplift loads. The clear span between the H-pile pads was 6m (20 ft) for the 9m (30 ft) long steel beams.
The loads were applied in steps of approximately 10 kN and after the grillage exhibited a notable amount of creep the load steps were decreased to 5 kN. Each load step was applied in approximately one minute.

ii) Lateral Load Tests on Earth Grillages

The lateral load test arrangements for both earth grillages are shown in Figures 13 to 16. An angle stub which was welded to a pulling plate was bolted to the projecting grillage angle. The horizontal loads to the grillage angle were applied 90 degrees to the line direction such that the grillage would moblize the maximum ground resistence. A bulldozer stationed 9m away, was used as a reaction. The winch line was laid on the ground and a 1m stroke double acting hydraulic cylinder was attached to apply the horizontal loads. A 20 kip dynomometer was connected in line to monitor the applied loads. A dial gauge attached to a steel batter board placed behind the grillage angle was used to measure the horizontal displacement.

After an initial load was applied, the loads were increased in steps of 0.5 kN. The loads were applied until the grillage angle exhibited a minimum horizontal displacement of 150mm or the hydraulic cylinder ran out of travel. Horizontal displacement readings were taken after each load increment or after each minute when the load was being maintained.

iii) Uplift Tests on Paired Rock Anchors

Appendix I also presents the test arrangement and test procedure that are used to test paired augered footings, H-piles or rock anchors. Figures 17 to 23 depict the actual test arrangements while Figures 24 and 25 detail the location and depth of the rock anchor "tell-tales".

The loads were applied by a pair of 900 kN (100 ton) capacity, hollow ram, hydraulic jacks. A pair of 27" W, 6m (20 ft) long, steel beams which rested on steel H-pile pads, were used for these tests. The clear span between the pads was typically 3m (10 ft). Special couplings were designed to adapt between the 1 3/4" diameter pulling rods and the 1" diameter rock anchors. These special couplings were required because not all the rock anchors were installed vertically. The couplings had a safe working load limit of 530 kN (120 kips) with a safety factor of 2. The two connectors can rotate up to 270 degrees in the X-axis and plus or minus 10 degrees about the Y and Z-axis.

The loads to each rock anchor were applied in steps of approximately 20 kN (4 kips). The rate of loading was approximately 100 kN (20 kips) per minute. The loads were increased until an anchor slipped or failed in the threads. When an anchor slipped, the loads to that anchor were temporarily decreased while the loads to the other anchor were continued until thread failure occurred. After the first anchor bolt failed, the other was reloaded until it too failed in the threads.

Test Results and Observations

The test results on the earth grillages and the paired rock anchors are summarized in Tables 1 and 2 respectively. Tables 3 to 12 give the detailed uplift and lateral movements while Figures 26 to 35 depict the load versus displacesment curves for all the tests.

i) Uplift Tests on Earth Grillages

The uplift tests on the earth grillages showed that even though both earth grillages at Tower 143 were installed 0.31m deeper than the same size grillages at Tower 84, they exhibited a pullout capacity that was only 40% of the pullout capacity of the grillages at Tower 84. Since all the grillages were of identical design, the difference in pullout resistance was due to soil properties. Except for a few soil "tell-tales" immediately next to the grillages, the other soil gauges registered relatively little soil uplift.

ii) Lateral Load Tests on Earth Grillages

Similar to the uplift tests, the lateral resistance of the tower leg at Tower 143 was 56% of the lateral capacity of the tower leg at Tower 84. Figure 36 depicts the tower leg at Tower 84 after completing the lateral load test.

iii) Uplift Tests on Paired Rock Anchors

a) Tower 145

In Test 7 on Tower leg 1, Figure 32 shows that initially the south anchor bolt displacement decreased with increasing loads. This was due to the anchor straightening out since this anchor bolt was installed at a slight angle. After the south anchor failed in the threads, the north anchor was reloaded. After exhibiting a total slip of 80mm, the north anchor also failed in the threads. Figure 37 depicts the south anchor pullout and thread failure of leg 2.

b) Tower 151

Figure 38 shows the north and south anchor bolt thread failures of leg 1. The north anchor exhibited a 125mm slip before it failed in the threads. Figure 39 depicts all the anchor bolt thread failures after completing all the rock anchor uplift tests. All the "tell-tales" showed relatively no rock displacement.

SUMMARY AND CONCLUSIONS

1) The uplift tests on earth grillages, installed 1.83m deep at Tower 143, exhibited pullout resistances of 55kN and 60kN for legs 2 and 4 respectively. The lateral test on leg 3 of the same tower produced a horizontal displacement of 122mm for an applied load of 10kN.

2) The uplift tests on earth grillages, installed 1.52m deep at Tower 84, exhibited pullout resistances of 145kN and 135kN for legs 2 and 4 respectively. The lateral load test on leg 1 of the same tower produced a horizontal displacement of 150mm for an applied load of 18kN.

3) Uplift tests on paired rock anchors at Towers 145 and 151 on legs 1 and 2 produced thread failures at loads which averaged 150kN on each anchor bolt.

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Appendix I

Uplift Test Arrangement and Test Procedures for Single and Paired Earth Grillages, Soil and Rock Anchors, H-Piles, and Augered Footings

a) Test Arrangement

The schematics for performing the uplift tests on single and paired foundations are shown in Figures 1 and 2 respectively. H-pile reaction pads, consisting of welded HP14x89 sections approximately 1.8m x 2.0m, are often stacked one on top of another and at right angles such that the top pad is also 90 degrees to the length of the loading beams. Sometimes, instead of these H-pile, 8 - WWF20x175 beams, each 7m (24 ft) long - 4 at each end, are used to create a larger reaction area especially when soft soil conditions are encountered. For some soil anchor tests timber pads, 1.5m x 1.8m (5ft x 6ft), are used.

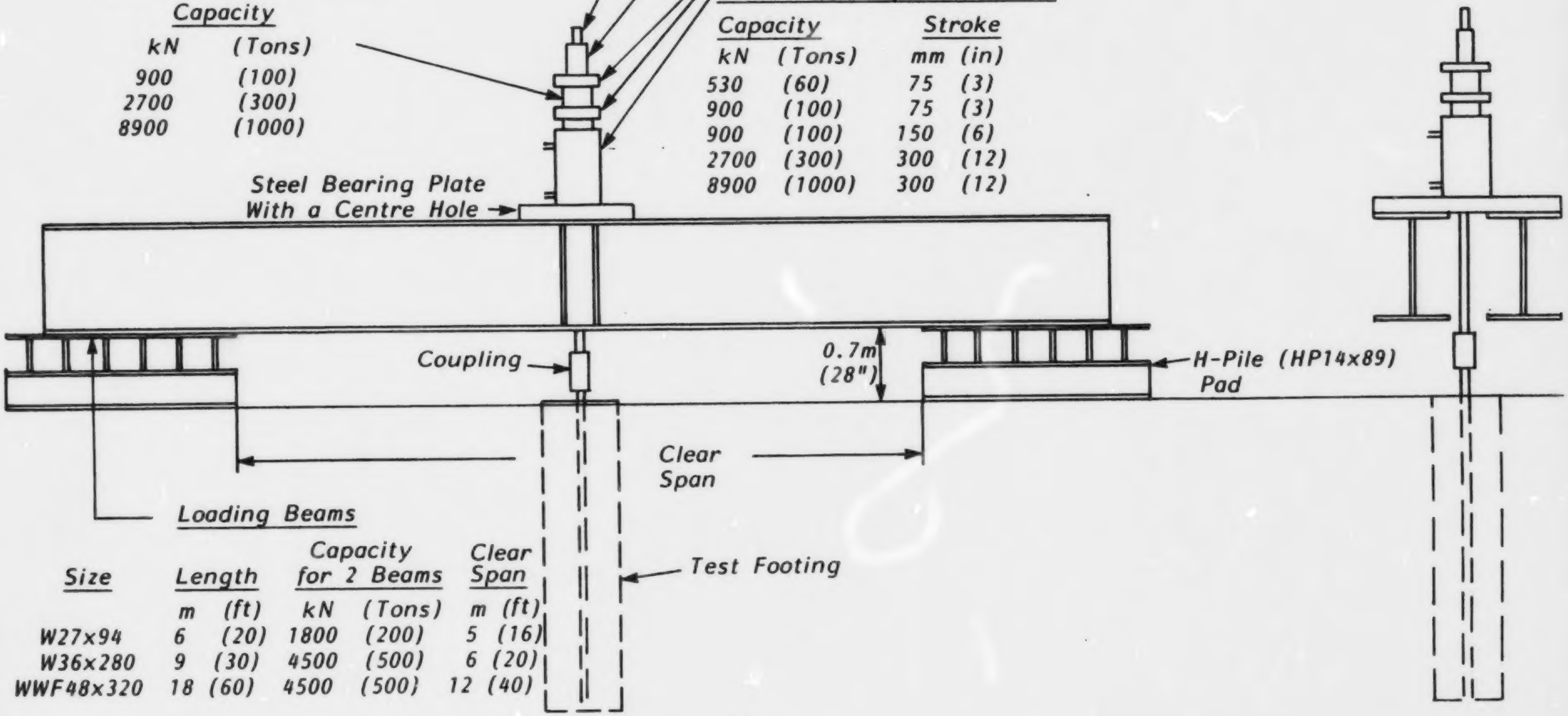
One of three sets of loading beams, (sizes, lengths and capacities are given in Figure 1), are used to support the hollow ram, hydraulic jacks. The selection of the loading beams is determined by the expected ultimate capacity of the anchorage and the required clear span. A clear span length of twice the anchorage installed depth (based on a 45 degree uplift cone), is a standard practice at Ontario Hydro. One or two of several sizes of hydraulic jacks, Figure 1 , are supported on steel bearing plates which rest on the loading beams. The steel bearing plates have one or two centre through holes for accommodating the steel pulling rods. Centre-hole compression load cells are used to monitor the applied load by each jack. The load cell capacity is matched to the capacity of the hydraulic jack. Three basic sizes and various lengths of threaded pulling rods are available for applying the uplift loads. Often Dywidag rebars with full tension couplers are used as pulling rods. Dywidag rebar has continuous threads and is supplied in various sizes and two steel strengths.

For performing angle pulls on single or a cluster of soil or rock anchors, special angle seats are bolted on top of the loading beams. When high angle loads are anticipated, the timber pads are buried for half their depth in soil and special beams and rods are used to prevent the beams from sliding horizontally on the timber pads. For high angle pull loads on rock anchors, a heavy bulldozer is stationed behind the loading beams.

Dial gauges or linear voltage displacement transformers (LVDT's) attached to steel or wood batter boards, placed below the loading beams, are used to record anchor or surrounding soil or rock uplifts. The batter boards rest on timbers which are placed well away from the zone of influence. The load cell and LVDT signals are fed to one or two X-Y recorders such that the load versus displacement plot can be obtained automatically. A computer controlled data acquisition system can also be used to simultaneously record many LVDT's with the applied load.

b) Test Procedures

The loads are applied in steps of approximately 10% of the expected failure load. The rate of loading is usually approximately 100 kN (25 kips) per munite with the 60 or 100 ton capacity hydraulic jacks and about twice that rate when the 300 or 1000 ton jacks are used. At each step all data is read and recorded. The load on each footing is maintained until the footing displacement has stopped or has appreciably subsided. The test is continued until the footing exhibits uplift failure or the applied load reaches the safe working load capacity of the loading beams or the pulling rods.



Steel Nut
Steel Plates With a Centre Hole
Steel Bearing Plate With a Centre Hole
Coupling
0.7m (28")
H-Pile (HP14x89) Pad
Clear Span
Test Footing

Pulling Rods

Diameter	Capacity kN	(kips)
1-1/4"	240	(55)
1-3/4"	490	(110)
3-1/2"	3100	(700)

Centre-Hole Hydraulic Jack

Capacity kN	(Tons)	Stroke mm	(in)
530	(60)	75	(3)
900	(100)	75	(3)
900	(100)	150	(6)
2700	(300)	300	(12)
8900	(1000)	300	(12)

Centre Hole Compression Load Cell

Capacity kN	(Tons)
900	(100)
2700	(300)
8900	(1000)

Loading Beams

Size	Length m	(ft)	Capacity for 2 Beams kN	(Tons)	Clear Span m	(ft)
W27x94	6	(20)	1800	(200)	5	(16)
W36x280	9	(30)	4500	(500)	6	(20)
WWF48x320	18	(60)	4500	(500)	12	(40)

FIGURE 1

SINGLE FOOTING UPLIFT TEST ARRANGEMENT

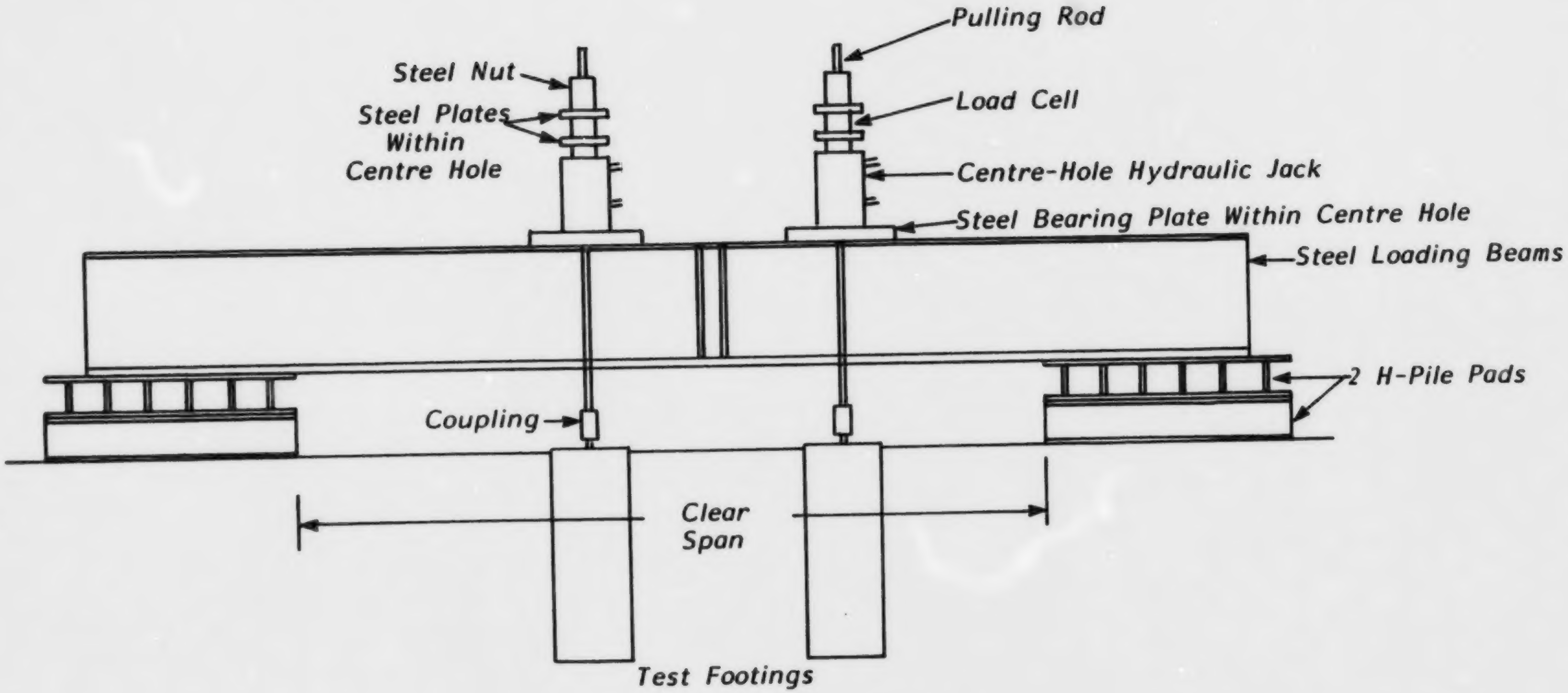

Pulling Rod
Steel Nut
Load Cell
Steel Plates Within Centre Hole
Centre-Hole Hydraulic Jack
Steel Bearing Plate Within Centre Hole
Steel Loading Beams
2 H-Pile Pads
Coupling
Clear Span
Test Footings

FIGURE 2

UPLIFT TEST ARRANGEMENT
FOR PAIRED FOOTINGS

TABLE 1

SUMMARY OF GRILLAGE TESTS

TEST NO	DATE OF TEST	TEST DESCRIPTION	DEPTH, m	MAXIMUM APPLIED LOAD, kN	RESULTING DISPLACEMENT, mm	TABLE NO	FIGURE NO
1	Feb 1/88	Grillage Uplift Test TWR 143 Leg 4	1.83	60	98.4	3	26
2	Feb 2/88	Grillage Uplift Test TWR 143 Leg 2	1.83	55	98.4	4	27
3	Feb 2/88	Grillage Lateral Load Test TWR 143 Leg 3	1.83	10	122.3	5	28
4	Feb 4/88	Grillage Uplift Test TWR 84 Leg 4	1.52	135	110+	6	29
5	Feb 4/88	Grillage Uplift Test TWR 84 Leg 2	1.52	145	101.6	7	30
6	Feb 5/88	Grillage Lateral Load Test TWR 84 Leg 1	1.52	18	149.6	8	31

TABLE 2

SUMMARY OF ROCK ANCHOR TESTS

TEST NO	DATE OF TEST	TOWER NO	LEG NO	SOUTH ANCHOR		NORTH ANCHOR		TABLE NO	FIGURE NO
				FAILURE LOAD kN	RESULTING UPLIFT, mm	FAILURE LOAD kN	RESULTING UPLIFT, mm		
7	Feb 8/88	145	1	145	25+	150	73.6	9	32
8	Feb 9/88	145	2	150	80+	165	33.0	10	33
9	Feb 10/88	151	1	150	43+	135	126+	11	34
10	Feb 10/88	151	2	150	50+	145	53	12	35

NOTE: All anchor bolts failed in the threads.

TABLE 3

GRILLAGE UPLIFT TEST

GRILLAGE UPLIFT TEST

TEST 1
FIGURE 26

Tower 143
Leg 4

Grillage Depth 1.83 m
Test Date - Feb 1/88

LOAD kN		GRILLAGE ANGLE		UPLIFT, mm SOIL "TELL-TALES"* 1	 2	 3	 4	 5	 6
			Depth (m)	0.30	1.37	1.37	1.07	1.07	0.91
10		3.18		0.13	0.12	2.25	0.18	0.13	0.10
20		6.60		0.46	0.42	6.35	0.64	0.51	0.40
35		10.16		0.56	0.55	10.80	1.04	0.68	0.46
45	Start	15.88		0.78	0.83	17.80	3.26	1.11	0.61
	5 min	25.40		0.98	1.15	25.10	3.48	1.59	0.87
60	Start	28.58		1.18	1.32	30.10	5.86	1.89	1.00
	4 min	-		1.49	1.82	51.10	8.16	2.68	1.27
	10 min	98.43		2.90	5.62+	99.80	9.86+	3.75	1.32

* see Figure 9

TABLE 4

GRILLAGE UPLIFT TEST

TEST 2　　Tower 143　　Grillage Depth 1.83 m

FIGURE 27　　Leg 2　　Test Date - Feb 2/88

LOAD kN		UPLIFT, mm							
		GRILLAGE ANGLE		SOIL "TELL-TALES"*					
		LVDT	DIAL GAUGE	1	2	3	4	5	6
			Depth(m)	0.30	1.37	1.37	1.07	1.07	0.91
5		0.64	0.19	0.00	-0.01	0.00	0.00	0.00	0.00
10		0.95	0.69	0.00	-0.01	-0.02	0.05	0.00	0.00
20	Start	2.86	4.11	0.04	0.02	0.02	0.70	0.05	0.00
	5 min	2.86	4.12	0.07	0.03	0.00	0.70	0.07	0.00
0		2.54	2.07	0.07	0.00	0.00	0.20	0.02	0.00
15		5.08	2.12	0.07	-0.01	-0.03	0.28	-0.01	-0.03
20		5.72	3.65	0.09	-0.01	-0.04	0.58	-0.01	-0.04
22	Start	5.72	4.75	0.10	0.01	-0.04	0.92	0.03	-0.04
	5 min	5.72	5.36	0.10	0.01	-0.02	1.02	0.07	-0.04
0		4.13	3.14	0.10	-0.03	-0.03	0.31	0.00	-0.03
10		4.45	5.05	0.13	-0.02	-0.05	0.90	0.02	-0.04
22	Start	6.99	5.55	0.13	-0.02	-0.04	1.03	0.06	-0.04
	5 min	6.99	6.00	0.09	-0.06	-0.04	1.14	0.09	-0.04
25	Start	7.62	6.50	0.09	-0.06	-0.01	1.50	[illegible]	-0.04
	5 min	-	7.95	0.07	-0.07	-0.22	1.92	0.28	-0.02
	10 min	9.53	8.22	0.06	-0.08	-0.39	2.00	0.30	-0.02
35	Start	10.16	8.75	0.09	-0.05	-0.49	2.40	0.43	0.01
	5 min	-	10.93	0.13	0.02	-0.99	2.97	0.56	0.02
	10 min	12.70	11.31	0.13	0.00	-1.07	3.10	0.57	0.02
40	Start	13.34	11.90	0.13	0.02	-1.19	3.30	0.66	0.03
	5 min	-	13.32	0.16	0.04		3.70	0.75	0.04
	10 min	15.24	13.55	0.16	0.02		3.73	0.76	0.04
45	Start	15.88	14.85	0.18	0.07		4.40	0.94	0.05
	2 min		18.65	0.23	0.18		5.10	1.12	0.06
	5 min		19.65	0.25	0.19		5.31	1.20	0.08
	10 min		20.55	0.27	0.19		5.41	1.25	0.08
	15 min	22.86	20.88	0.22	0.13		5.45	1.25	0.08
50	Start	23.50	23.55	0.22	0.14		6.00	1.44	0.09
	2 min		31.05	0.23	0.24		7.02	1.80	0.11
	5 min		33.35	0.23	0.25		7.24	1.92	0.12
	10 min		35.75	0.23	0.25		7.49	2.01	0.12
	15 min		38.75	0.25	0.25		7.66	2.08	0.12
	20 min		40.75	0.26	0.23		7.76	2.08	0.15
	25 min		42.25	0.24	0.19		7.91	2.12	0.15
	30 min		44.05	0.24	0.19		8.08	2.15	0.16
	31 min	48.90	44.45	0.25	0.19		8.12	2.15	0.12
55	Start	50.17	47.45	0.29	0.24		8.49	2.33	0.12
	1 min		57.45	0.33	0.30		9.39	2.53	0.14
	2 min		64.45	0.36	0.36		9.99	2.65	0.16
	5 min		77.45+	0.49	0.53		10.70	2.95	0.31
	9 min			0.49	0.53		11.08	3.10	0.32
	10 min	98.40		0.49	0.53		11.16	3.13	0.32

* See Figure 10

TABLE 5
GRILLAGE LATERAL LOAD TEST

TEST 3	TWR 143	GRILLAGE DEPTH 1.83 m	TEST DATE
FIGURE 28	LEG. 3		FEBRUARY 2, 1988

LOAD kN		HORIZONTAL DISPLACEMENT*, mm
4.0		29.56
5.0	START	32.21
	1 MIN	36.91
	2 MIN	38.41
	3 MIN	39.31
	4 MIN	40.31
	5 MIN	40.81
	6 MIN	41.31
5.5	7 MIN	41.71
	8 MIN	41.91
	9 MIN	42.20
	10 MIN	42.37
6.5	START	45+
7.0	1 MIN	55+
7.5	2 MIN	60+
8.0	3 MIN	63+
	4 MIN	70+
	5 MIN	80+
8.5	6 MIN	84.5
8.5	8 MIN	87.5
9.0	9 MIN	90.5
	10 MIN	92.8
	11 MIN	95.0
	12 MIN	96.5
	13 MIN	97.5
	14 MIN	98.4
	15 MIN	99.2
	17 MIN	100.4
10.0	START	102.0
	1 MIN	106.5
	2 MIN	109.0
	3 MIN	111.1
	4 MIN	113.3
	5 MIN	114.5
	6 MIN	116.0
	7 MIN	117.9
	8 MIN	119.4
	9 MIN	120.7
	10 MIN	122.3

* Measured approximately 50 mm above ground level

TABLE 6

GRILLAGE UPLIFT TEST

TEST 4 Tower 84 Grillage Depth 1.52 m
FIGURE 29 Leg 4 Test Date - Feb 4/88

LOAD kN		UPLIFT, mm						
		GRILLAGE ANGLE		SOIL "TELL-TALES"*				
		LVDT	DIAL GAUGE	1	2	4	5	6
			Depth (m)	0.30	1.37	1.07	1.07	0.91
10		0.64	0.06	-0.01	0.01	0.00	0.00	0.01
15		1.27	0.95	-0.03	0.01	0.00	0.00	0.01
20		2.54	2.25	-0.02	0.01	0.03	0.01	0.01
30	Start	3.18	2.95	0.00	0.06	0.04	0.01	0.01
	4 min	4.76	3.73	-0.04	0.15	0.07	0.05	0.03
35	Start	5.72	4.35	-0.09	0.21	0.09	0.05	0.03
	5 min	-	5.96	-0.11	0.38	0.09	0.05	0.01
	10 min	6.99	6.20	-0.10	0.44	0.14	0.05	0.04
40	Start	6.99	6.85	-0.10	0.49	0.16	0.05	0.05
	5 min	9.52	7.87	-0.02	0.54	0.32	0.21	0.21
45	Start	9.52	8.45	+0.05	0.79	0.43	0.23	0.22
	5 min	-	9.35	0.14	0.92	0.58	0.33	0.32
	10 min	13.34	10.83	0.15	1.28	0.61	0.41	0.38
55	Start	13.34	11.31	0.09	1.25	0.66	0.41	0.32
	2 min	13.97	12.09	-0.08	1.24	0.66	0.24	0.18
60	Start	14.61	13.20	-0.13	1.27	0.66	0.24	0.18
	5 min	16.51	15.26	-0.09	1.19	0.68	0.24	0.17
65	Start	17.15	15.91	0.08	1.69	0.99	0.24	0.17
	5 min	19.69	18.86	0.69	1.88	1.80	0.55	0.57
70	Start	20.96	20.11	0.80	2.00	2.12	0.64	0.63
	5 min	23.50	22.61	1.02	2.44	2.45	0.79	0.77
75	Start	26.04	24.41	1.03	2.72	2.90	0.94	0.89
	5 min	31.12	25.81	1.26	2.95	3.25	1.06	1.05
85	Start	31.12	27.01	1.29	3.09	3.47	1.14	1.10
	5 min	35.56	32.51	1.33	3.53	3.90	1.21	1.15
90	Start	35.56	33.51	1.39	3.66	4.08	1.28	1.18
	5 min	-	40.41	1.47	4.19	4.85	1.54	1.24
	10 min	46.36	42.51	1.60	4.48	5.21	1.52	1.39
100		46.99	44.86	1.56	4.79		1.39	1.45
102		55.25		1.59	-			
0		38.74		0.57	2.45			1.62
130		100.97		-	6.15			
0		80+		-0.11	6.41		1.26	1.40
135		110		0.29	10.94		2.88	1.45

* See Figure 11

TABLE 7

GRILLAGE UPLIFT TEST

TEST 5 Tower 84 Grillage Depth 1.52 m
FIGURE 30 Leg 2 Test Date - Feb 4/88

LOAD kN		UPLIFT, mm								
		GRILLAGE ANGLE			SOIL "TELL-TALES"*					
		LVDT	DIAL GAUGE		1	2	3	4	5	6
				Depth (m)	0.30	1.37	1.37	1.07	1.00	0.89
10		0.64	0.83		0.06	0.05	0.01	0.04	0.04	0.01
20		3.81	3.60		0.06	0.06	0.03	0.09	0.07	0.02
35	Start	5.08	6.92		0.08	0.07	0.08	0.19	0.15	0.03
	5 min	7.30	7.98		0.17	0.15	0.24	0.28	0.22	0.07
45	Start	8.89	10.40		0.20	0.20	0.30	0.43	0.33	0.09
	5 min	10.80	11.40		0.24	0.25	0.49	0.52	0.38	0.11
55	Start	11.75	16.70		0.28	0.30	0.62	0.78	0.54	0.13
	5 min	13.97	18.02		0.34	0.40	0.86	0.90	0.68	0.17
0		10.16	13.62		0.34	0.37	0.52	0.52	0.32	0.18
60	Start	15.24	19.60		0.40	0.45	0.92	0.96	0.73	0.20
	5 min	16.51	20.00		0.45	0.52	1.09	1.08	0.82	0.26
70	Start	19.05	20.70		0.49	0.59	1.19	1.30	1.01	0.26
	5 min	20.00	24.37		0.52	0.64	1.60	1.49	1.18	0.30
80	Start	20.96	26.80		0.56	0.74	1.90	1.88	1.51	0.32
	5 min	-	28.90		0.59	0.80	2.47	2.72	1.85	0.37
	10 min	26.35	30.05		0.63	0.86	2.66	2.43	2.00	0.40
0		19.05	24.15		0.74	0.69	1.26	2.11	0.84	0.41
80	Start	27.96	33.24		0.85	0.97	2.75	3.59	2.01	0.43
	5 min	29.21	34.66		0.92	1.06	3.06	3.80	2.21	0.47
95	Start	32.39	36.84		0.96	1.18	3.50	4.26	2.65	0.48
	5 min	37.47	43.04		0.96	1.34	4.44	4.98	3.28	0.51
110	Start	41.91	47.84		0.99	1.54	4.85	5.73	3.76	0.53
	5 min	48.90	54.84		0.99	1.57	6.40	6.87	5.05	0.56
120	Start	50.80	58.04		0.99	1.50	7.00	7.03	5.93	0.58
	5 min	-			0.99	1.63	9.43	8.77	8.01	0.59
	10 min	54.61								
130		55.25								
		57.79								
145		101.60								
0		78.11			1.40	2.10	15.99	9.17	7.38	0.77

* See Figure 12

TABLE 8

GRILLAGE LATERAL LOAD TEST

TEST 6 FIGURE 31	TWR 184 LEG. 1	GRILLAGE DEPTH 1.52. m	TEST DATE FEBRUARY 5, 1988

LOAD kN		HORIZONTAL DISPLACEMENT*, mm
2.5	START	11.71
3.0	1 MIN	14.01
3.5	3 MIN	15.41
4.0	5 MIN	15.96
5.0	START	17.31
7.5	1 MIN	23.91
8.0	2 MIN	26.21
8.5	3 MIN	27.51
8.5	4 MIN	28.71
8.5	5 MIN	29.41
10.0	START	33.61
11.0	1 MIN	40.61
12.0	2 MIN	59.11
13.0	3 MIN	74.11
13.5	4 MIN	84.11
14.0	5 MIN	92.11
14.0	6 MIN	100.11
14.5	7 MIN	105.61
14.5	8 MIN	112.11
14.5	9 MIN	115.61
15.0	10 MIN	122.61
15.0	11 MIN	124.11
15.0	12 MIN	125.21
17.0	START	133.11
17.5	1 MIN	143.11
18.0	2 MIN	149.61

* Readings were taken 250 mm above ground level

TABLE 9

ROCK ANCHOR UPLIFT TEST

TEST 7	Tower 145	Depth 1.22 m
FIGURE 32	Leg 1	Test Date - Feb 8/88

LOAD kN	UPLIFT, mm								
	ROCK ANCHOR			ROCK "TELL-TALES"*					
	SOUTH	NORTH		1	2	3	4	5	6
			Depth (m)	0.61	0.91	1.30	0.76	0.51	0.25
20	-0.32	0.64		0.01	0.01	0.01	0.00	0.01	0.01
35	-3.18	0.95		0.01	0.01	0.01	0.00	0.01	0.01
55	-4.45	1.27		0.03	0.03	0.02	0.00	0.02	0.03
75	-5.08	2.22		0.06	0.05	0.05	0.01	0.03	0.04
95	-4.45	3.18		0.08	0.06	0.06	0.03	0.05	0.06
110	-0.64	6.99		0.09	0.08	0.07	0.04	0.05	0.06
130	6.35	11.75		0.11	0.11	0.11	0.04	0.07	0.07
145	25+	40.00							
150		73.60		0.12	0.32	0.12	0.06	0.08	0.09
0				0.08	0.17	0.17	0.06	0.13	0.15

* See Figure 24

TABLE 10

ROCK ANCHOR UPLIFT TEST

TEST 8	Tower 145	Depth 1.22 m
FIGURE 33	Leg 1	Test Date - Feb 9/88

LOAD kN	UPLIFT, mm								
	ROCK ANCHOR			ROCK "TELL-TALES"*					
	SOUTH	NORTH		1	2	3	4	5	6
			Depth (m)	0.61	0.91	1.30	0.76	0.51	0.25
20.00	0.00	0.64		0.00	0.00	0.00	0.00	0.00	0.00
35.00	0.16	1.91		0.00	0.00	0.00	0.00	0.00	0.00
55.00	0.32	3.81		0.00	0.00	0.00	0.00	0.00	0.00
75.00	0.64	4.45		0.00	0.00	0.00	0.00	0.00	0.00
95.00	1.59	5.40		0.00	0.00	0.00	0.00	0.00	0.00
115.00	4.45	7.94		0.01	0.00	0.00	0.00	0.00	0.00
140.00	10.80	13.97		0.01	0.01	0.00	0.03	0.02	0.01
150.00	80+	26.67		0.01	0.01	-0.02	0.04	0.03	0.01
165.00		33.02		-	-	-	-	-	-
0.00				-	-	-	0.06	0.04	0.03

* See Figure 24

TABLE 11

ROCK ANCHOR UPLIFT TEST

TEST 9	Tower 151	Depth 1.22 m
FIGURE 34	Leg 1	Test Date - Feb 10/88

LOAD kN	UPLIFT, mm								
	ROCK ANCHOR			ROCK "TELL-TALES"*					
	SOUTH	NORTH		1	2	3	4	5	6
			Depth (m)	0.56	1.02	1.30	0.76	0.51	0.25
15	1.91	1.59		0	0	0	0	0	0
35	4.45	2.54		0	0	0	0	0	0
55	4.76	3.18		0	0	0	0	0	0
75	5.08	3.81		0	0	0	0	0	0
100	5.72	5.08		0	0	0	0	0	0
110	8.26	7.62		0	0	0	0	0	0
125	13.34	21.60							
135	16.51	126+							
150	43+								

* See Figure 25

TABLE 12

ROCK ANCHOR UPLIFT TEST

TEST 10 Tower 151 Depth 1.22 m
FIGURE 35 Leg 2 Test Date - Feb 10/88

LOAD kN	UPLIFT, mm								
	ROCK ANCHOR			ROCK "TELL-TALES"*					
	SOUTH	NORTH		1	2	3	4	5	6
			Depth (m)	0.56	1.02	1.30	0.76	0.51	0.25
15	1.27	0.64		0	0	0	0.02	0.02	0
35	2.54	1.27		0	0	0.01	0.02	0.02	0
55	3.81	1.91		0	0	0.01	0.02	0.02	0
75	4.45	2.54		0	0	0.01	0.03	0.04	0.02
95	5.40	3.18		0	0	0.01	0.03	0.04	0.02
110	7.62	6.99		0	0	0.01	0.03	0.04	0.02
135	48.90	53+		0	0	0.02	0.03	0.04	0.02
150	50+								

* See Figure 25

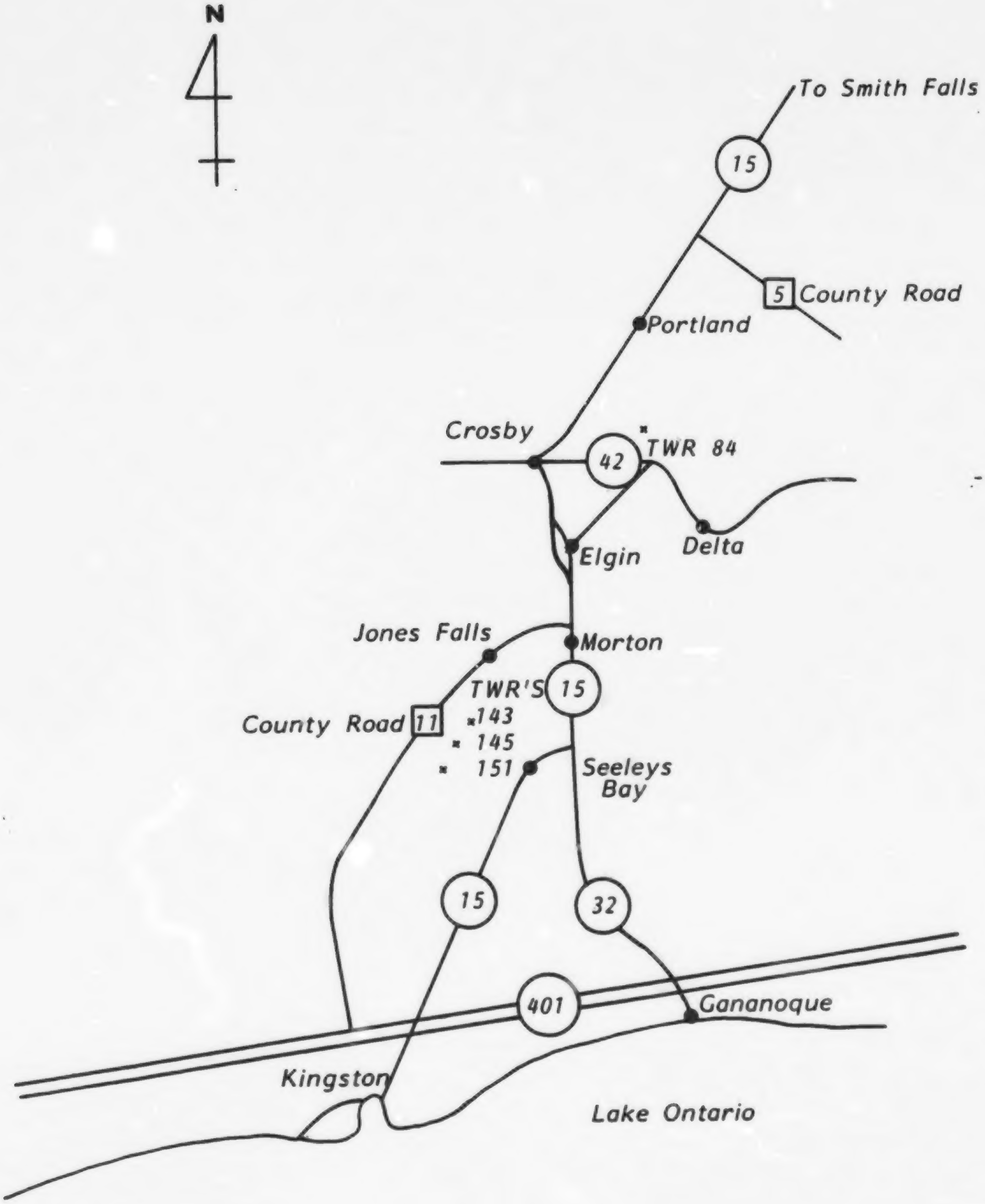

N
To Smith Falls
15
5 County Road
Portland
Crosby
42
TWR 84
Elgin
Delta
Jones Falls
Morton
TWR'S
15
143
145
151
County Road 11
Seeleys Bay
15
32
401
Gananoque
Kingston
Lake Ontario

FIGURE 1
GENERAL LOCATION OF TOWERS

177497-RD

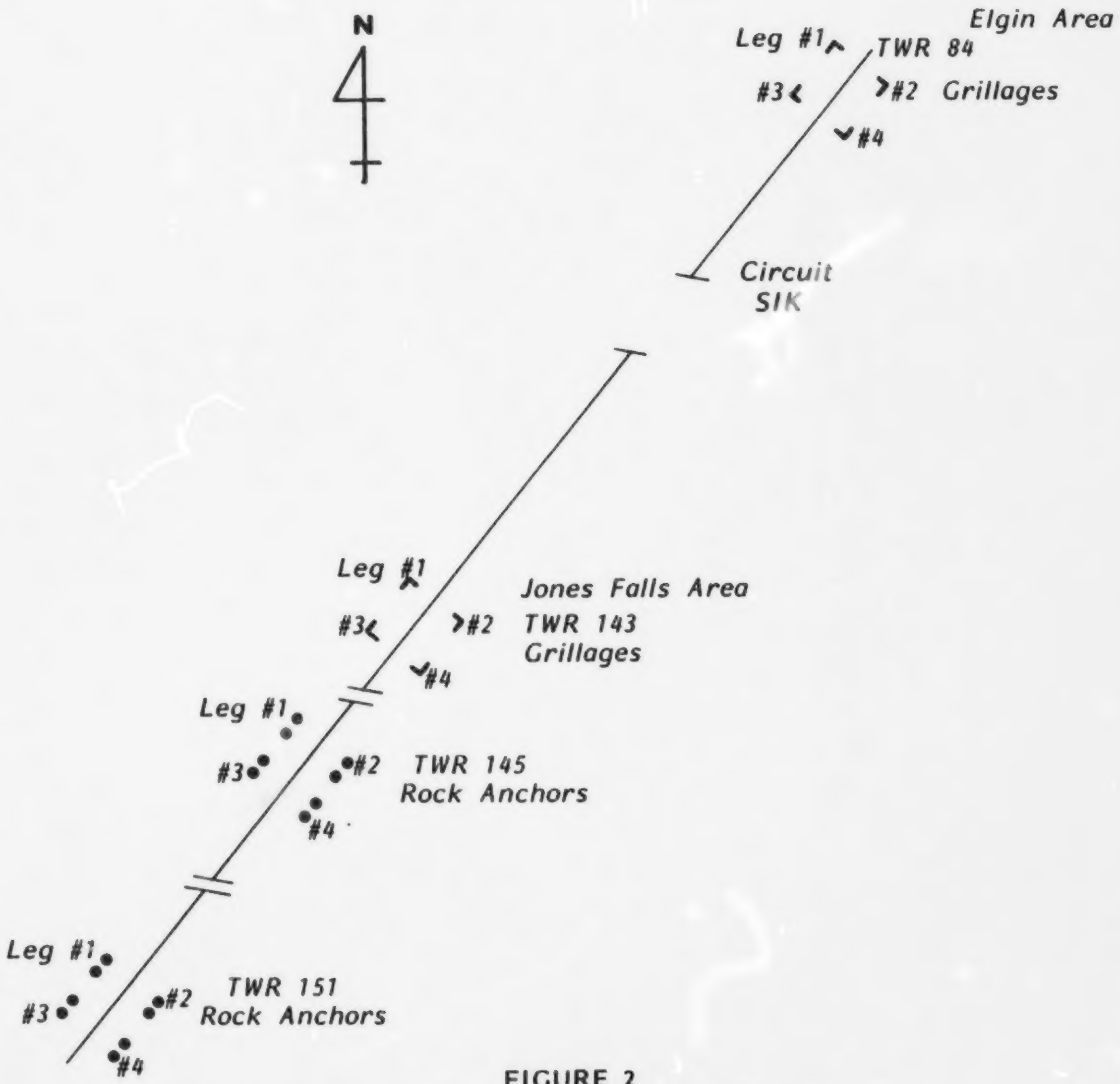
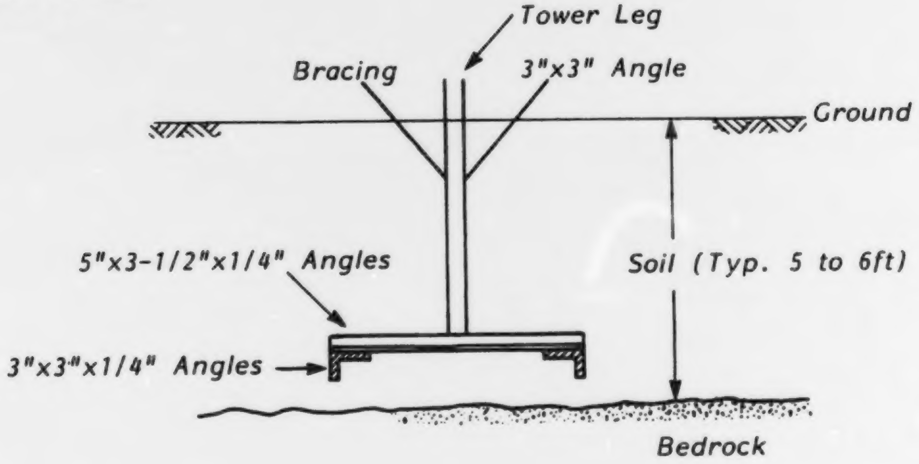

N
Elgin Area
Leg #1
TWR 84
#3
#2
Grillages
#4
Circuit
SIK
Leg #1
Jones Falls Area
#3
#2
TWR 143
Grillages
#4
Leg #1
#3
#2
TWR 145
Rock Anchors
#4
Leg #1
#3
#2
TWR 151
Rock Anchors
#4

FIGURE 2

LOCATION OF ROCK ANCHOR AND GRILLAGE TEST SITES

Cross Section


Tower Leg
Bracing
3"x3" Angle
Ground
5"x3-1/2"x1/4" Angles
Soil (Typ. 5 to 6ft)
3"x3"x1/4" Angles
Bedrock

Plan

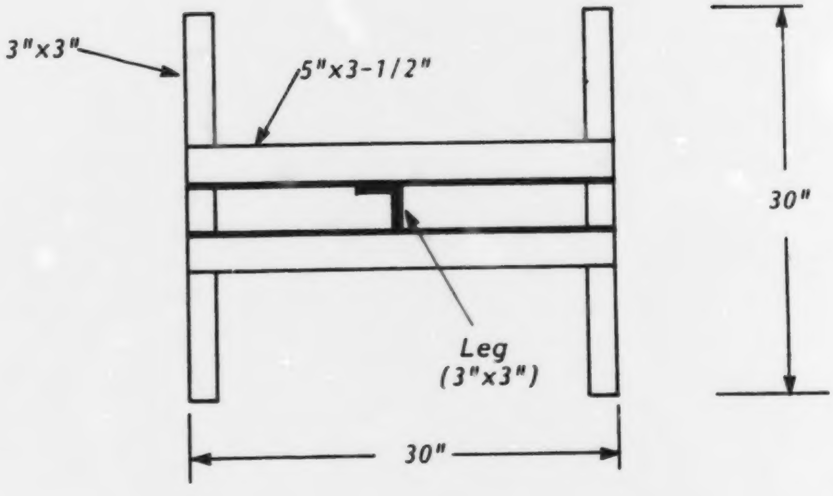

3"x3"
5"x3-1/2"
30"
Leg
(3"x3")
30"

FIGURE 3

EARTH GRILLAGE CONSTRUCTION DETAILS
(TOWER #84 AND #143)

FIGURE 4
AN EXCAVATED EARTH GRILLAGE

FIGURE 5

GRILLAGE UPLIFT TEST ARRANGEMENT
AT TWR 143 LEG 2

FIGURE 6

GRILLAGE UPLIFT TEST ARRANGEMENT
AT TWR 84 LEG 2

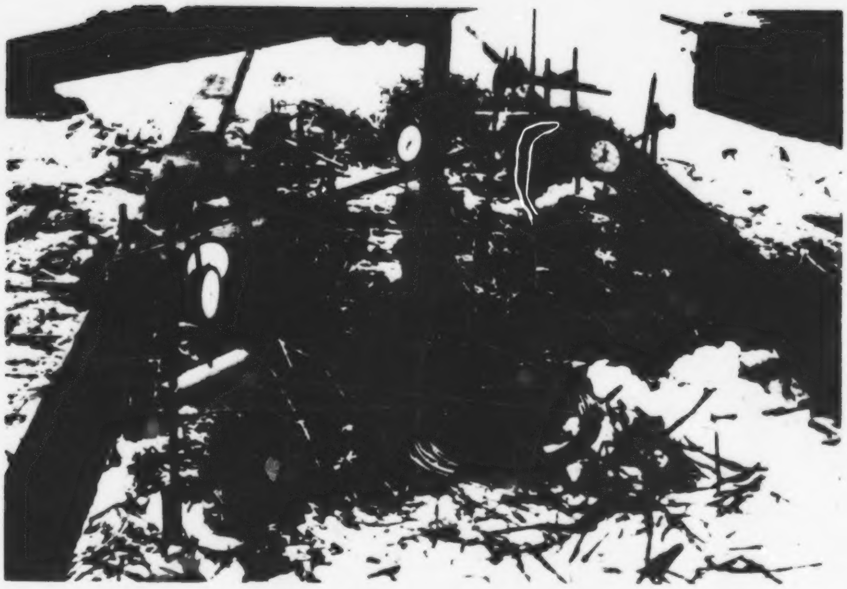


FIGURE 7

LVDT AND DIAL GAUGES FOR
MEASURING GRILLAGE AND SOIL UPLIFT

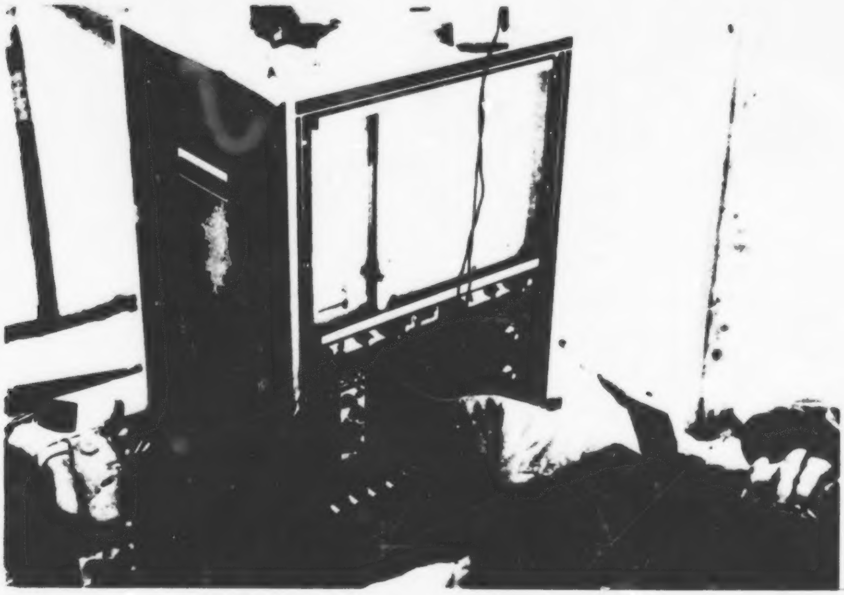
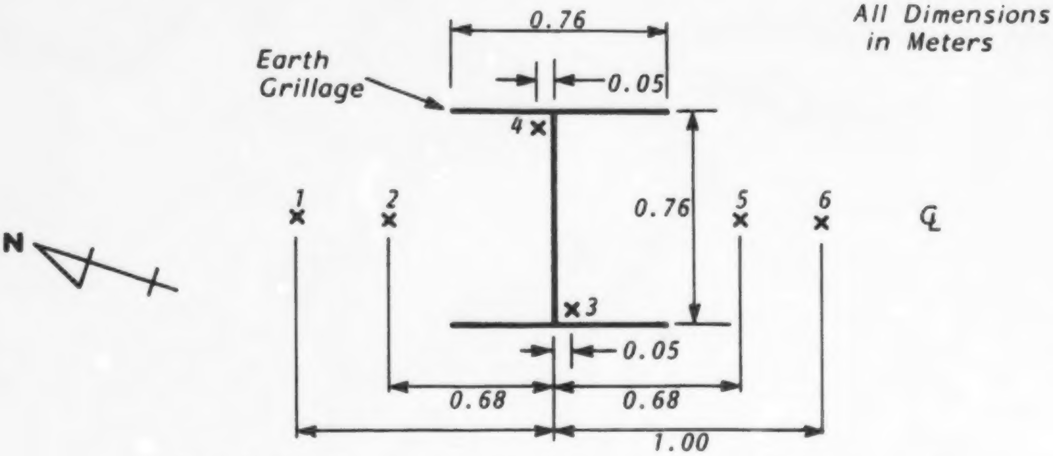


FIGURE 8

X-Y RECORDER PRODUCING A LOAD
VERSUS UPLIFT CURVE FOR THE GRILLAGE UPLIFT TESTS

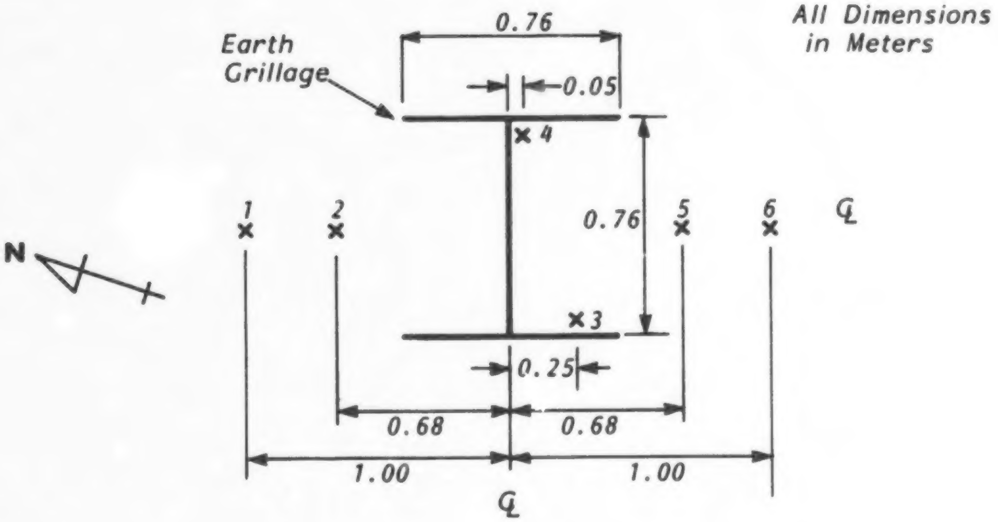
177489-RD
Bart 3 Disk


All Dimensions in Meters
Earth Grillage
0.76
0.05
4
3
1
2
5
6
0.76
0.05
0.68
0.68
1.00
N
℄

Tell-Tale No	1	2	3	4	5	6
Depth, m	0.30	1.37	1.37	1.07	1.07	0.91

FIGURE 9

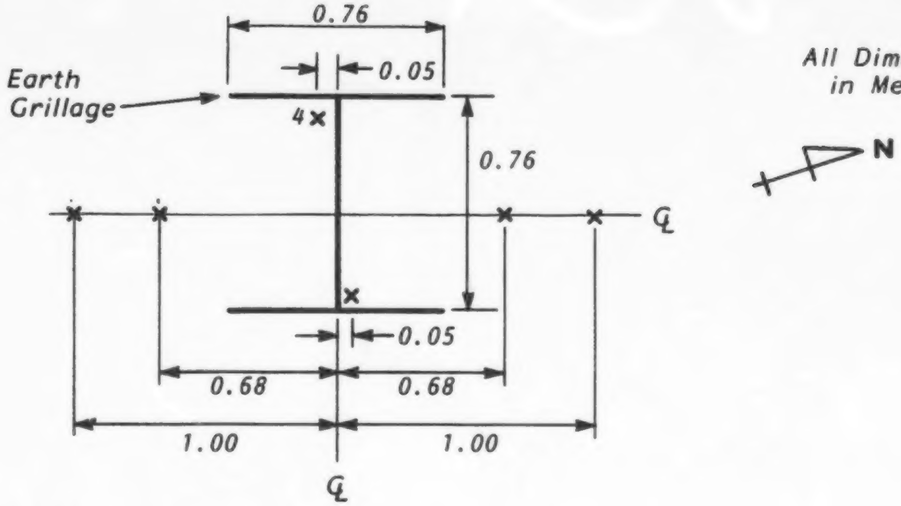
TELL-TALE LOCATIONS AND DEPTHS FOR TOWER 143, LEG 4


All Dimensions in Meters
Earth Grillage
0.76
0.05
4
3
1
2
5
6
0.76
0.25
0.68
0.68
1.00
1.00
N
℄
℄

Tell-Tale No	1	2	3	4	5	6
Depth, m	0.30	1.37	1.37	1.07	1.07	0.91

FIGURE 10

TELL-TALE LOCATIONS AND DEPTHS FOR TOWER 143, LEG 2

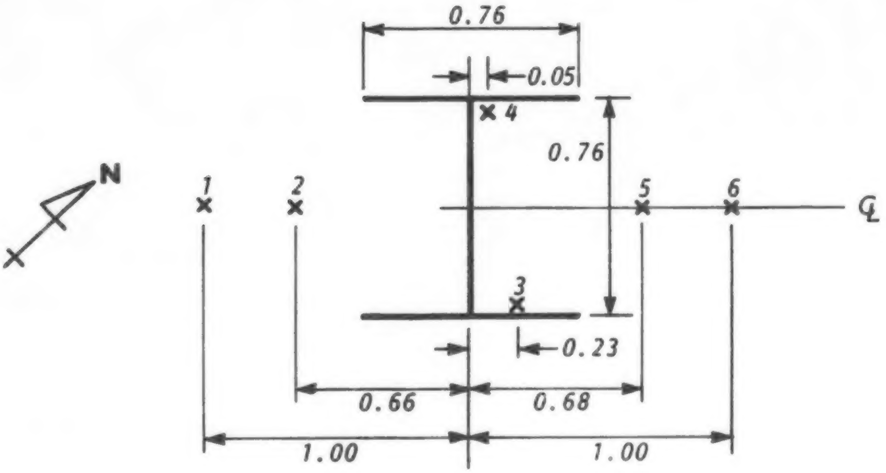

0.76
0.05
Earth Grillage
4
0.76
N
℄
0.05
0.68
0.68
1.00
1.00
℄

All Dimensions in Meters

Tell-Tale No	1	2	3	4	5	6
Depth, m	0.30	1.37	1.37	1.07	1.07	0.91

FIGURE 11

TELL-TALE LOCATIONS AND DEPTHS FOR TOWER 84, LEG 4


0.76
0.05
4
0.76
N
1
2
5
6
℄
3
0.23
0.66
0.68
1.00
1.00

All Dimensions in Meters

Tell-Tale No	1	2	3	4	5	6
Depth, m	0.30	1.37	1.37	1.07	1.00	0.89

FIGURE 12

TELL-TALE LOCATIONS AND DEPTHS FOR TOWER 84, LEG 2

FIGURE 13

LATERAL LOAD TEST ON
GRILLAGE LEG #3
AT TWR 143

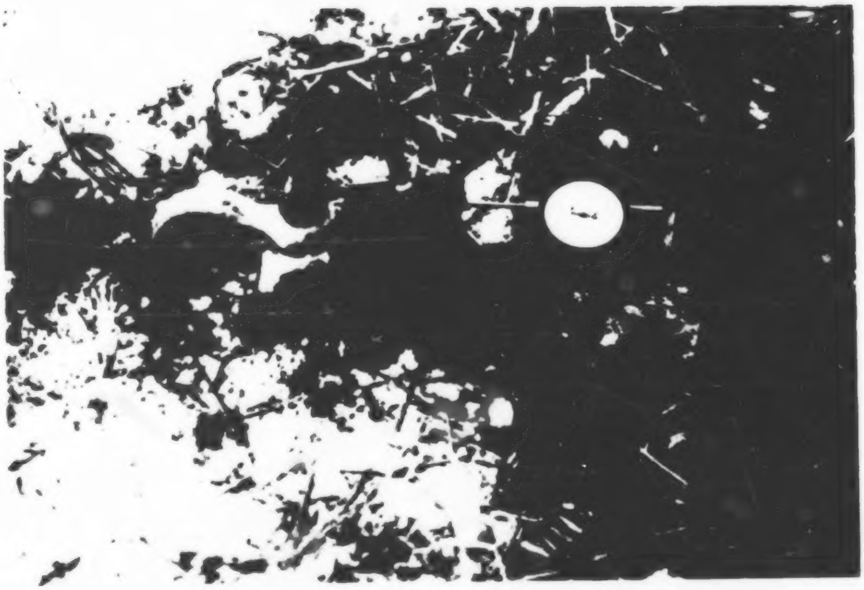


FIGURE 14

DIAL GAUGE MEASURING GRILLAGE LEG
HORIZONTAL DISPLACEMENT FOR ABOVE TEST

177490 RD
Bart 3 Disk

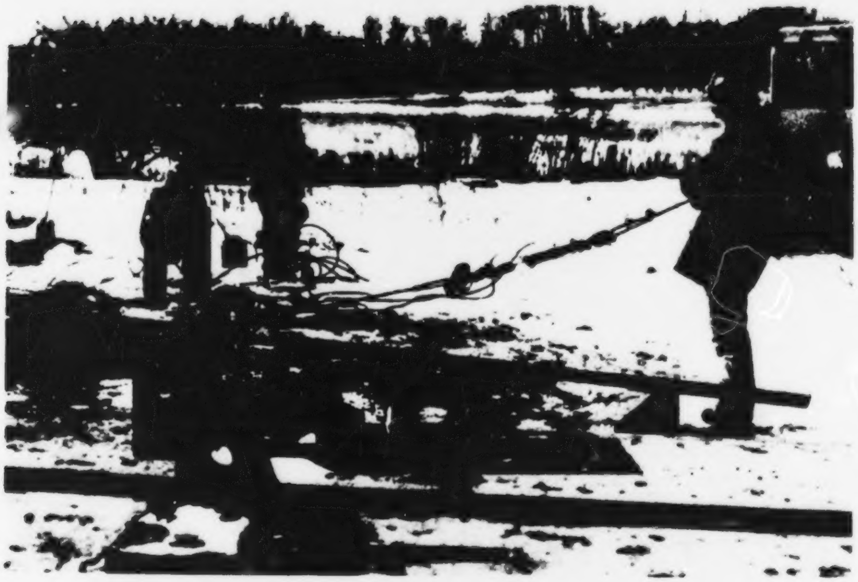


FIGURE 15

LATERAL LOAD TEST ON
GRILLAGE LEG 1 AT TWR 84

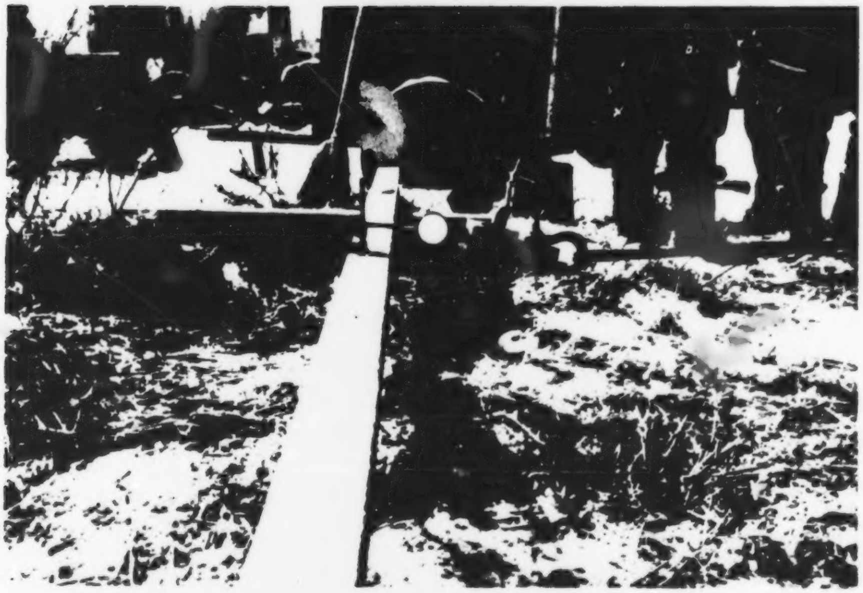


FIGURE 16

DIAL GAUGE MEASURING GRILLAGE LEG
HORIZONTAL DISPLACEMENT FOR ABOVE TEST

177491-RD
Bart 3 Disk

FIGURE 17

ROCK ANCHOR UPLIFT TEST ARRANGEMENT
AT TWR 151 LEG 1

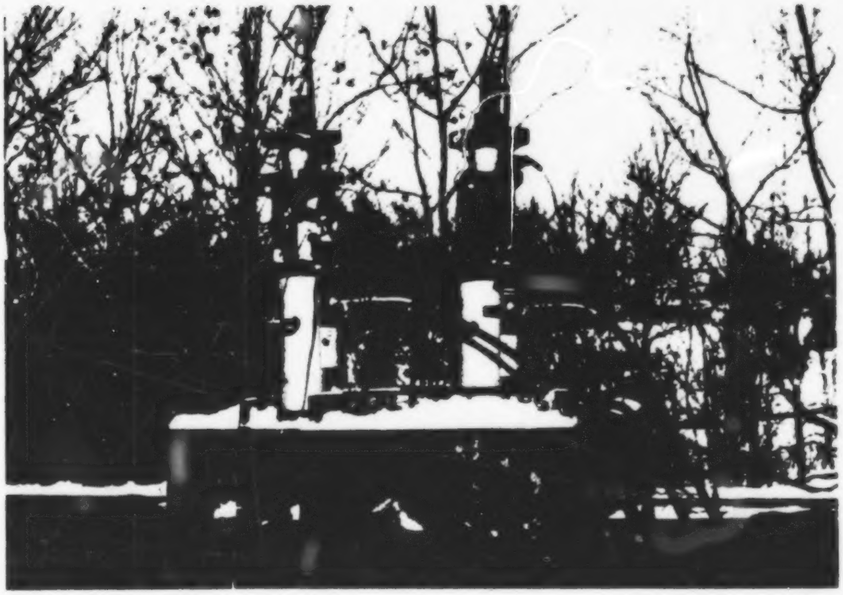


FIGURE 18

HYDRAULIC JACKS AND LOAD CELLS
FOR ABOVE TEST

177492-RD
Bart 3 Disk

FIGURE 19

ROCK ANCHOR UPLIFT TEST ARRANGEMENT
AT TWR 145 LEG 2

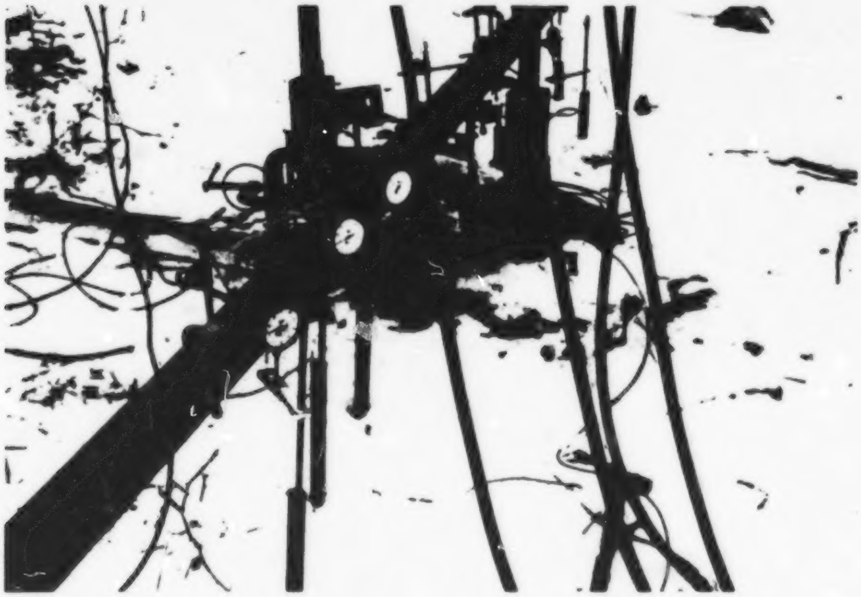


FIGURE 20

INSTRUMENTATION FOR MEASURING
ROCK AND ROCK ANCHOR UPLIFT
FOR ABOVE TEST

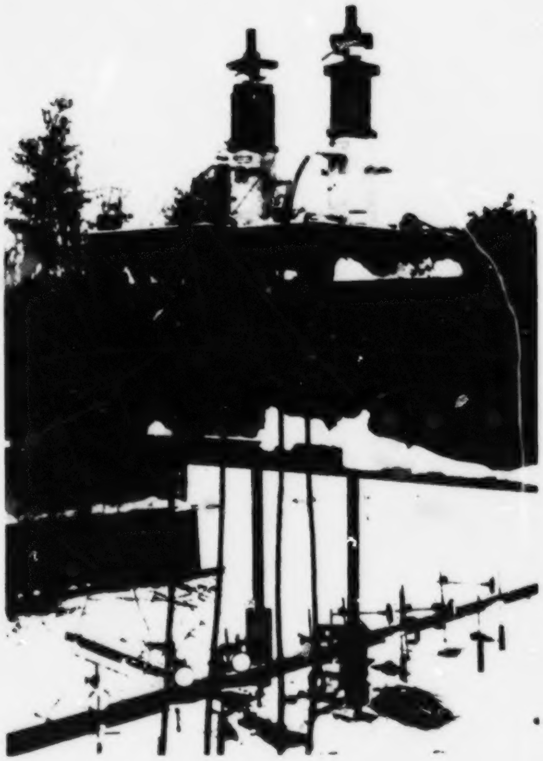


FIGURE 21

CLOSE-UP OF THE PULLING HARDWARE ARRANGEMENT

FIGURE 22

CLOSE-UP OF SPECIAL ROCK ANCHOR COUPLINGS

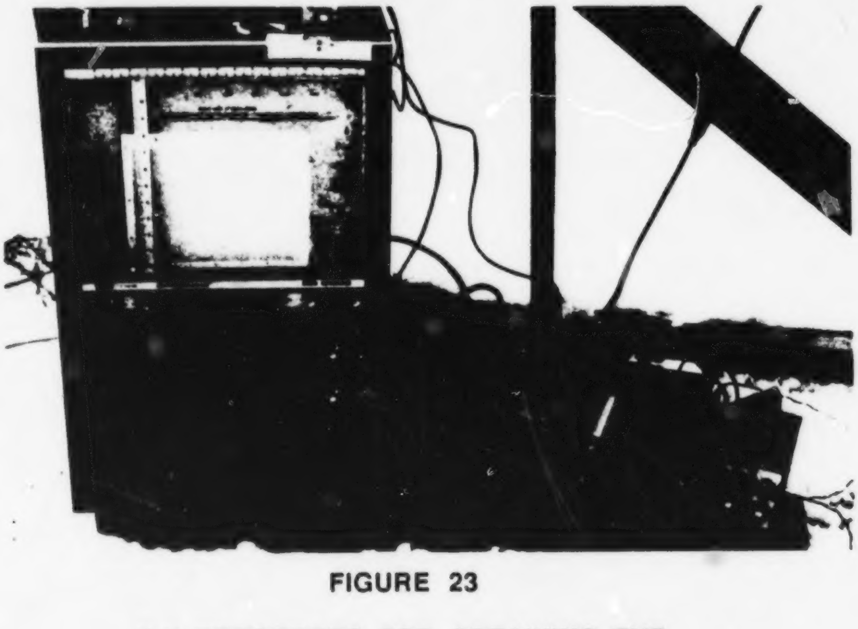
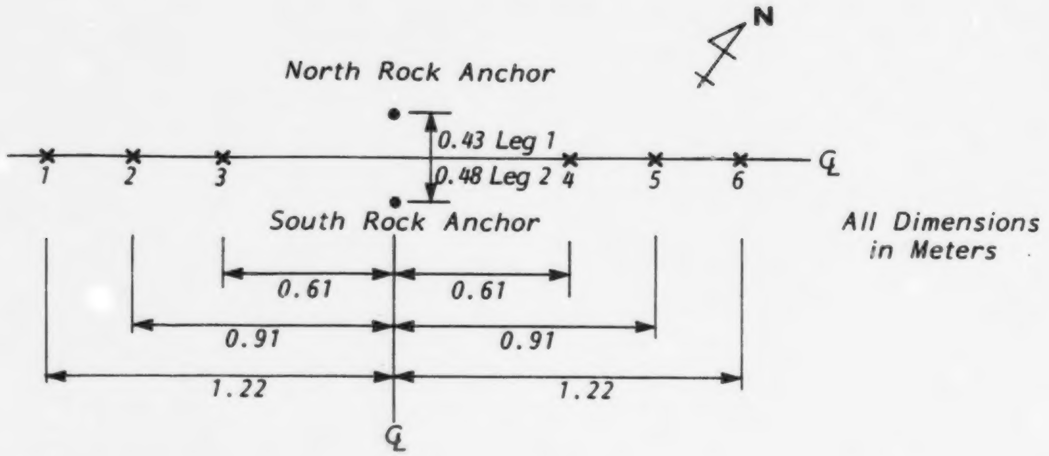


FIGURE 23

X-Y RECORDERS FOR OBTAINING THE LOAD VERSUS UPLIFT CURVE FOR THE ROCK ANCHOR UPLIFT TESTS

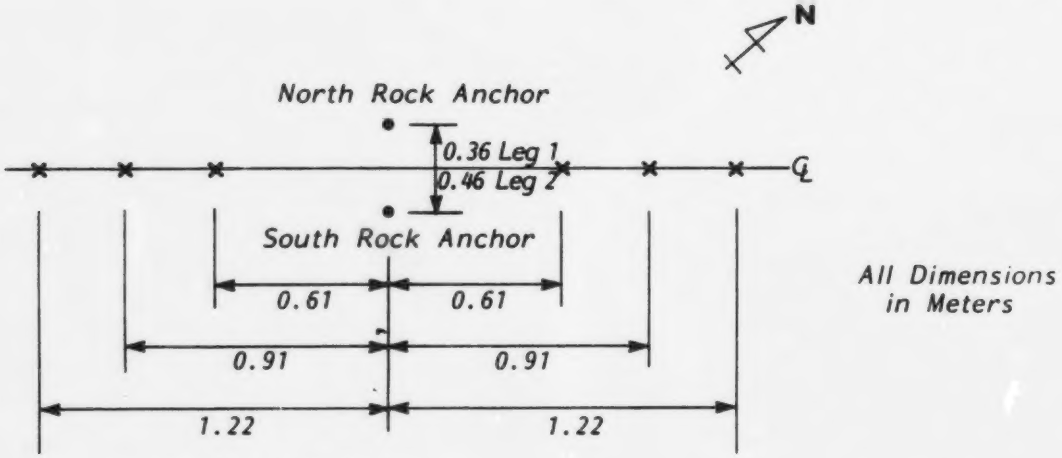
177494-RD
Bart 3 Disk


N
North Rock Anchor
0.43 Leg 1
0.48 Leg 2
1
2
3
4
5
6
℄
South Rock Anchor
All Dimensions in Meters
0.61
0.61
0.91
0.91
1.22
1.22
℄

Tell-Tale No	1	2	3	4	5	6
Depth, m	0.61	0.91	1.30	0.76	0.51	0.25

FIGURE 24

TELL-TALE LOCATIONS AND DEPTHS FOR TOWER 145, LEGS 1 AND 2


N
North Rock Anchor
0.36 Leg 1
0.46 Leg 2
℄
South Rock Anchor
All Dimensions in Meters
0.61
0.61
0.91
0.91
1.22
1.22

Tell-Tale No	1	2	3	4	5	6
Depth, m	0.56	1.02	1.30	0.76	0.51	0.25

FIGURE 25

TELL-TALE LOCATIONS AND DEPTHS FOR TOWER 151, LEGS 1 AND 2

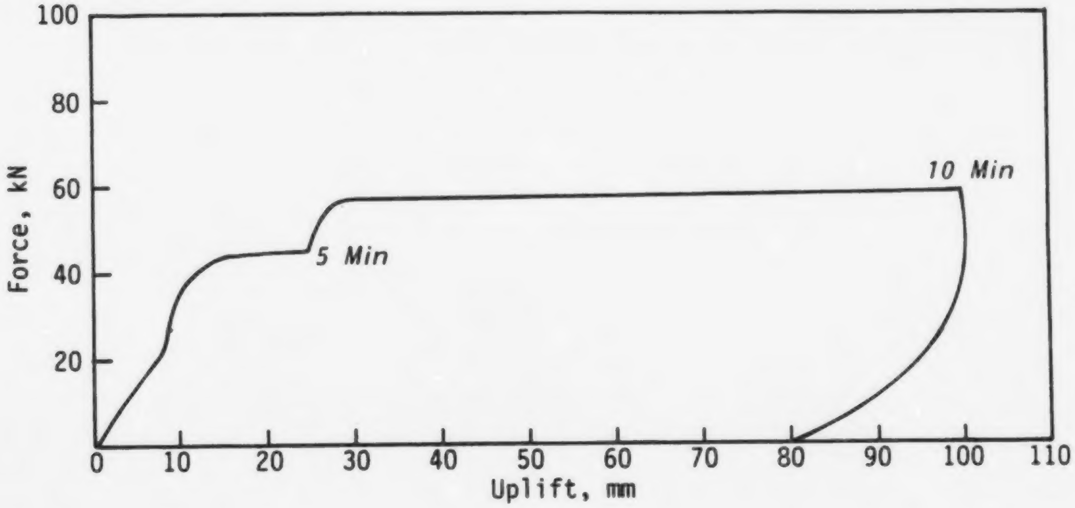


FIGURE 26

LOAD VERSUS UPLIFT CURVE FOR
GRILLAGE IN TEST 1
TOWER 143, LEG 4

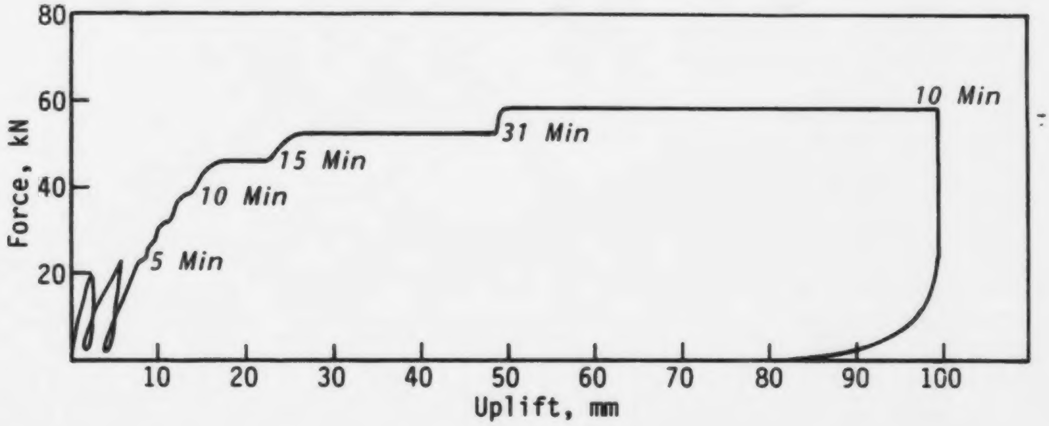


FIGURE 27

LOAD VERSUS UPLIFT CURVE FOR
GRILLAGE IN TEST 2
TOWER 143, LEG 2

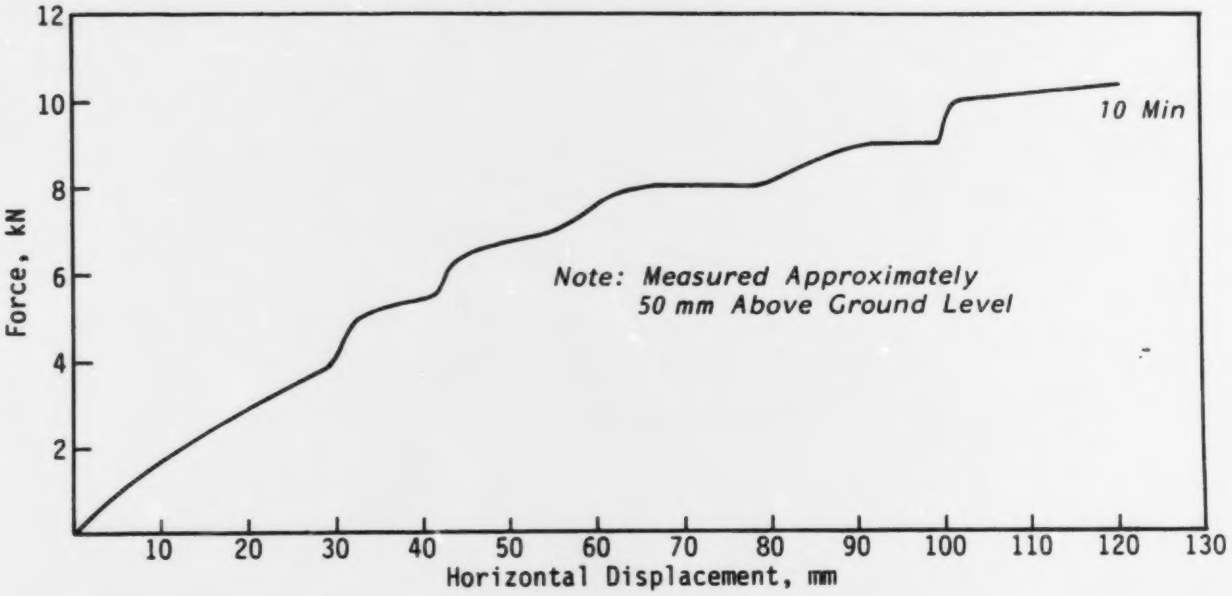


FIGURE 28

LOAD VERSUS HORIZONTAL DISPLACEMENT
OF GRILLAGE IN TEST 3
TOWER 143, LEG 3

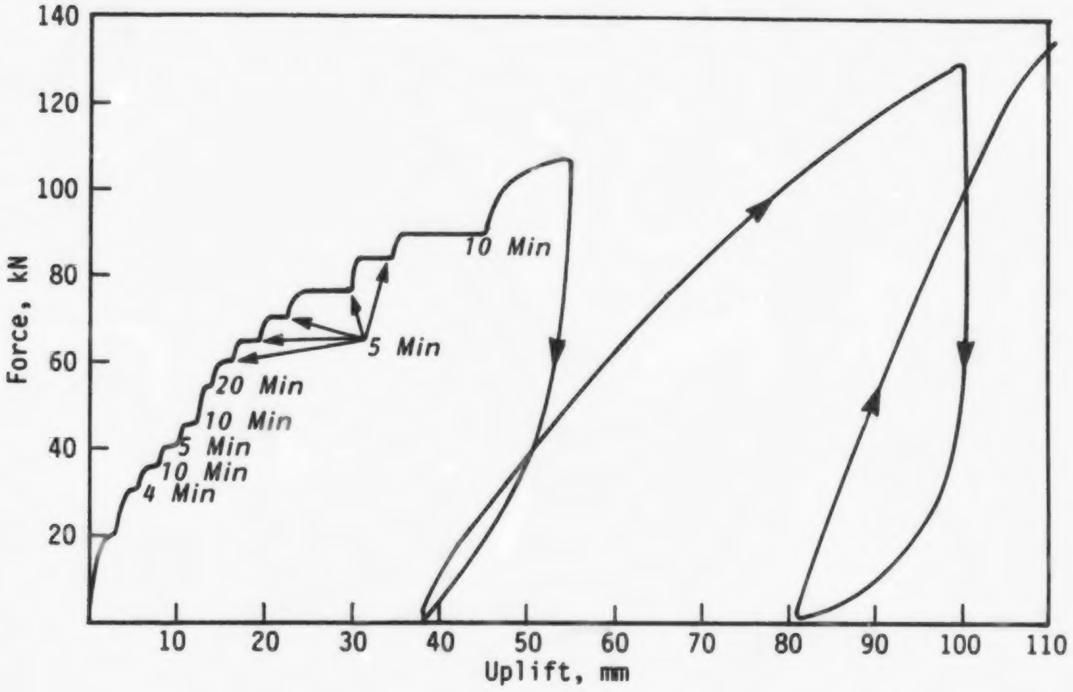


FIGURE 29

LOAD VERSUS UPLIFT CURVE FOR
GRILLAGE IN TEST 4
TOWER 84, LEG 4

177507-RD

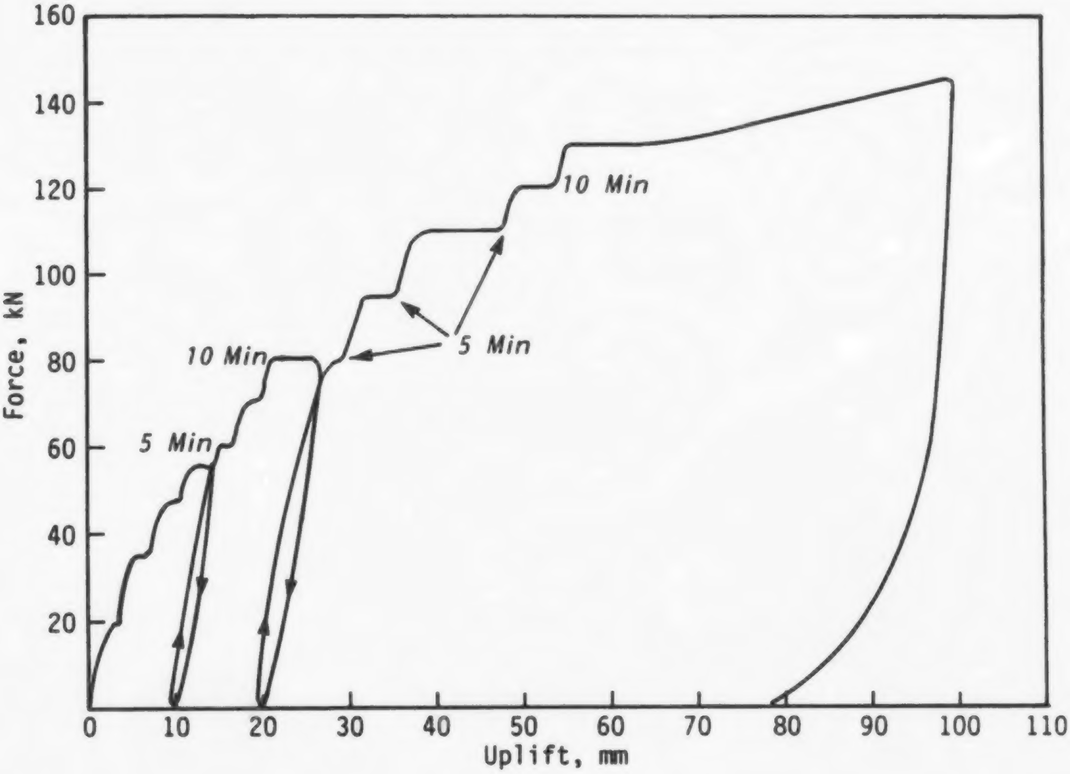


FIGURE 30

LOAD VERSUS UPLIFT CURVE FOR
GRILLAGE IN TEST 5
TOWER 84, LEG 2

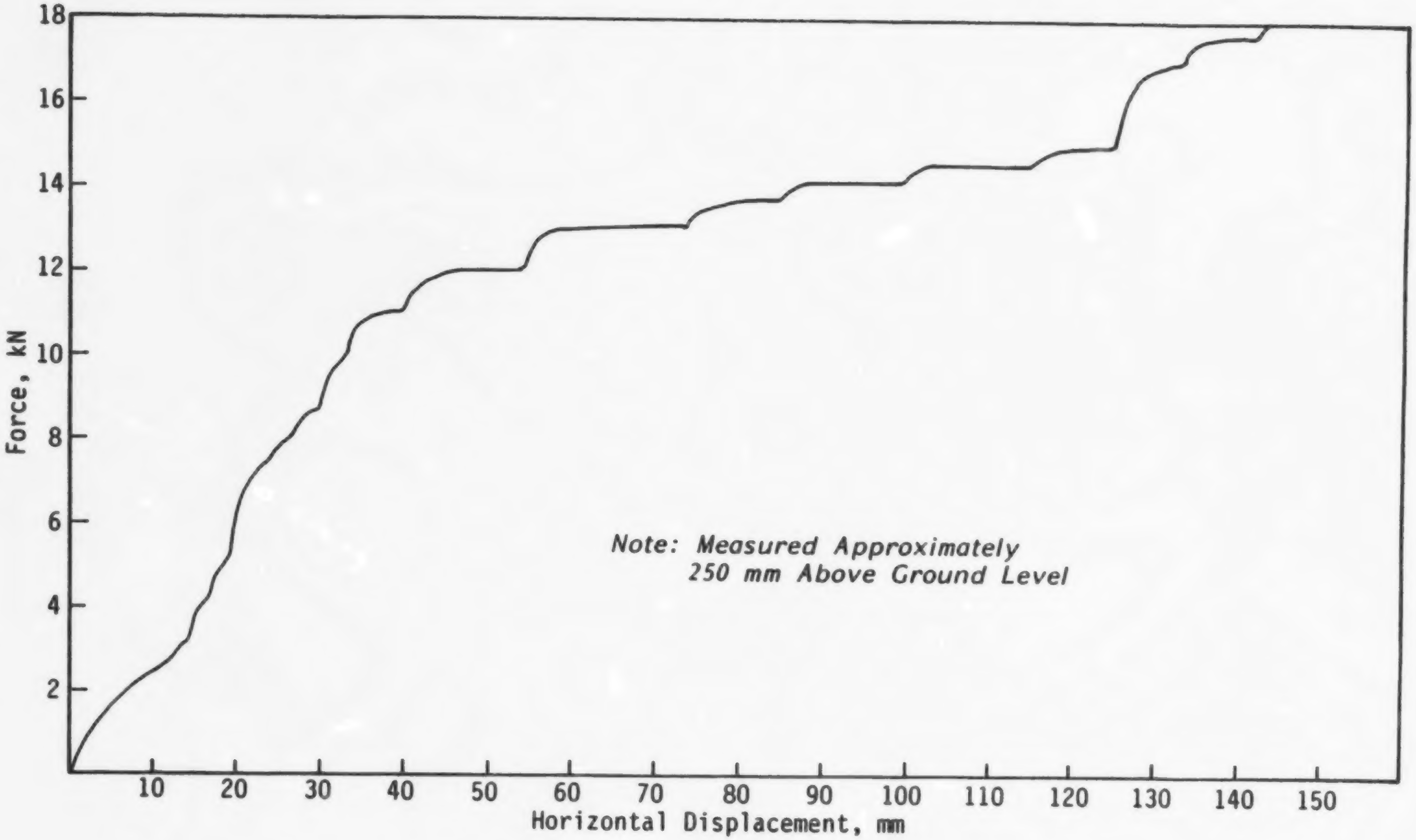


FIGURE 31

LOAD VERSUS HORIZONTAL DISPLACEMENT
OF GRILLAGE IN TEST 6
TOWER 84, LEG 1

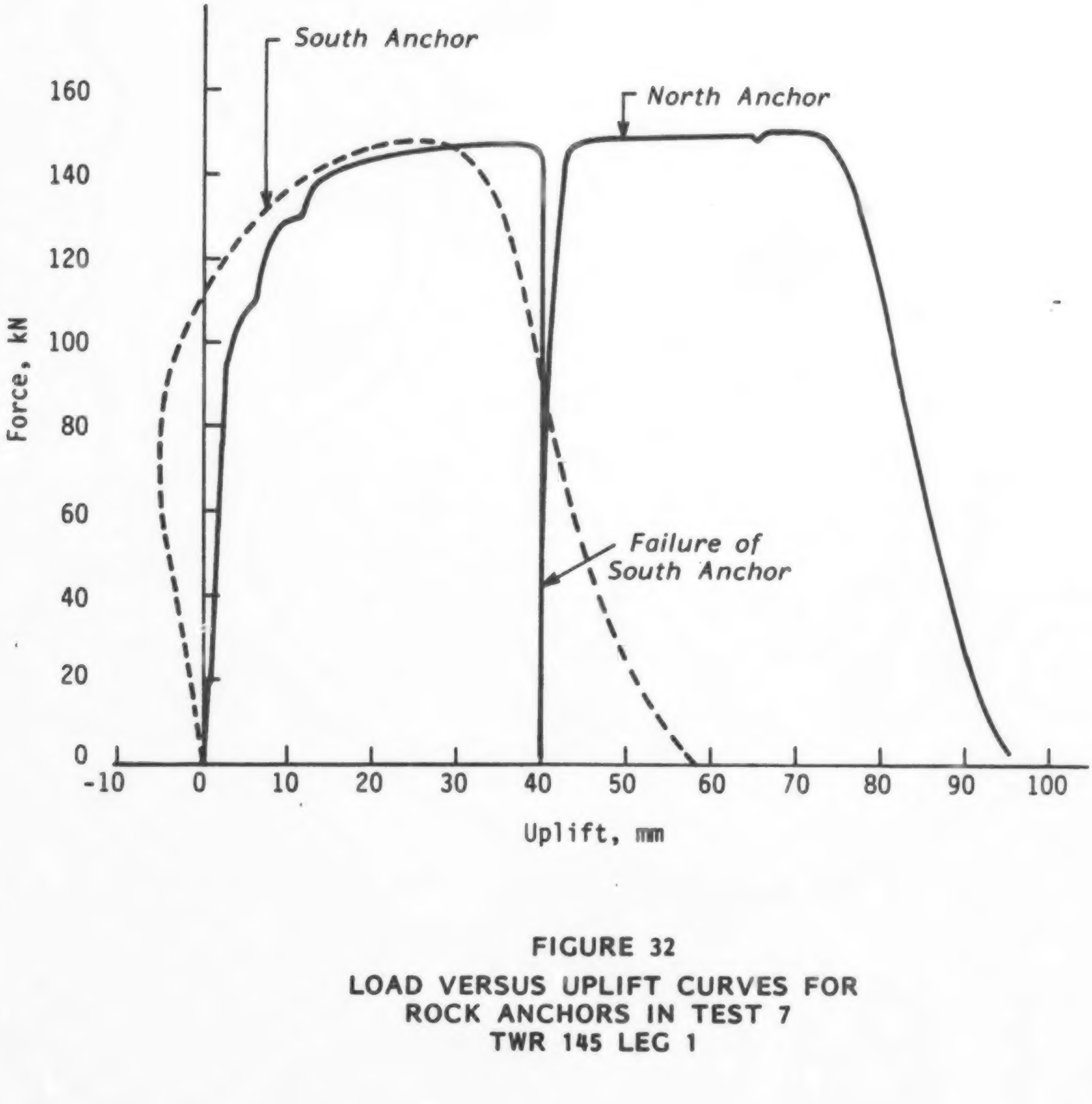


FIGURE 32
LOAD VERSUS UPLIFT CURVES FOR
ROCK ANCHORS IN TEST 7
TWR 145 LEG 1

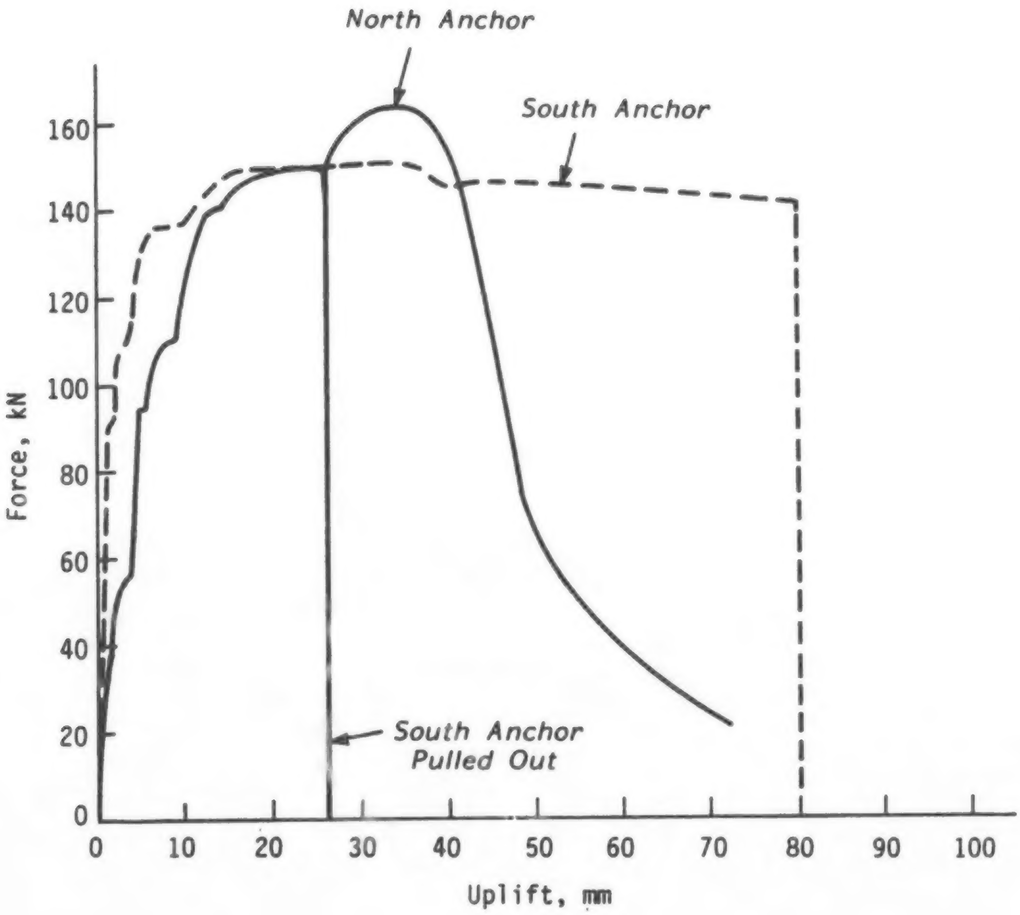


FIGURE 33

LOAD VERSUS UPLIFT CURVES FOR ROCK ANCHORS IN TEST 8 TWR 145 LEG 2

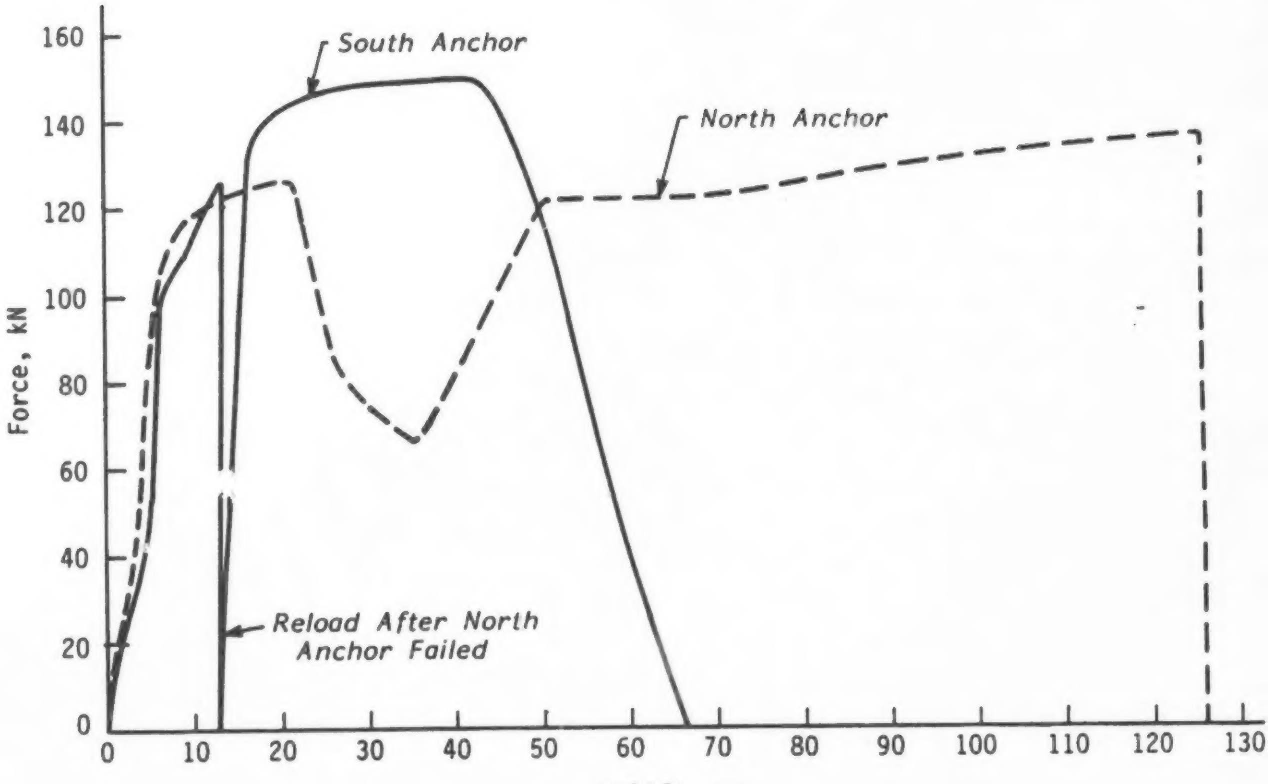


FIGURE 34

LOAD VERSUS UPLIFT CURVES FOR ROCK ANCHORS IN TEST 9 TWR 151 LEG 1

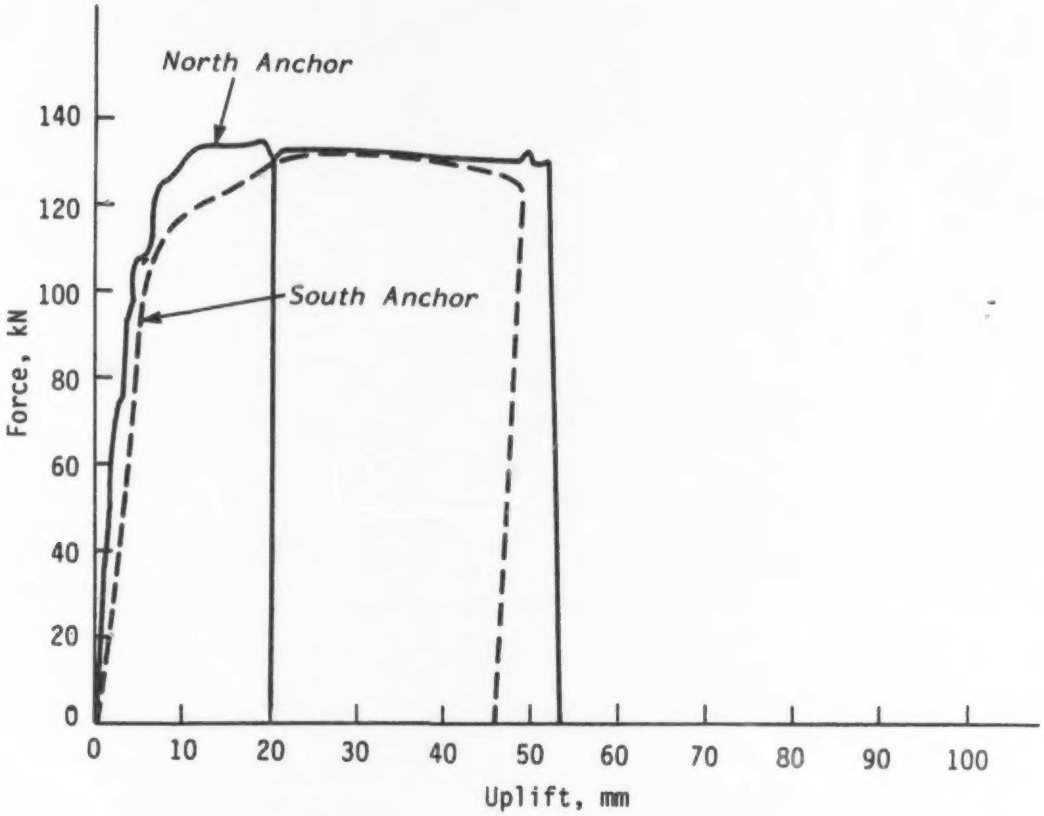


FIGURE 35

LOAD VERSUS UPLIFT CURVES FOR ROCK ANCHORS IN TEST 10 TWR 151 LEG 2

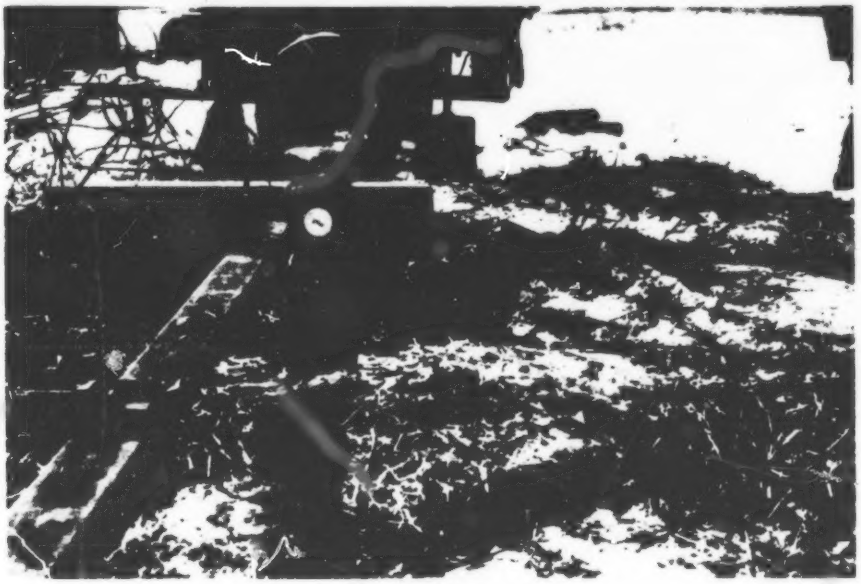


FIGURE 36

UPON COMPLETING GRILLAGE LATERAL LOAD TEST
TEST 6, TWR 84 LEG 1

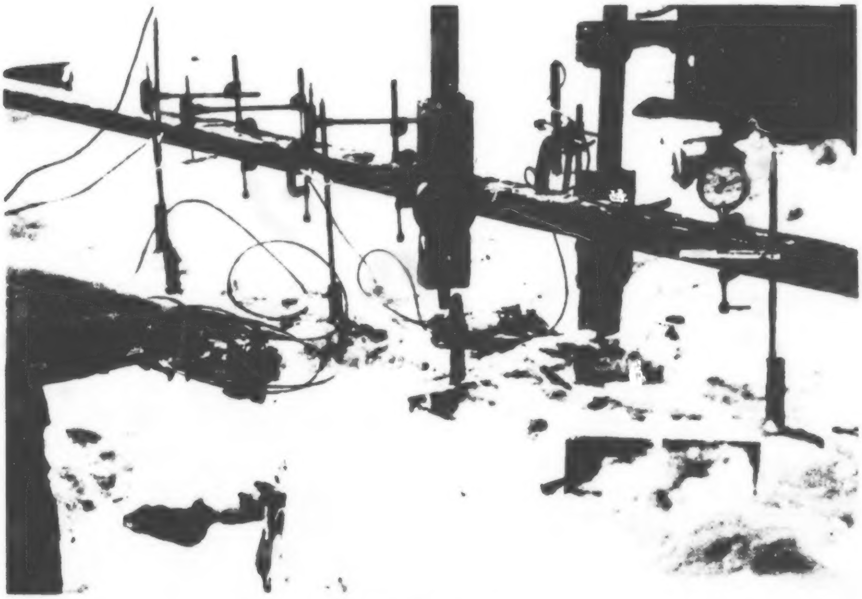
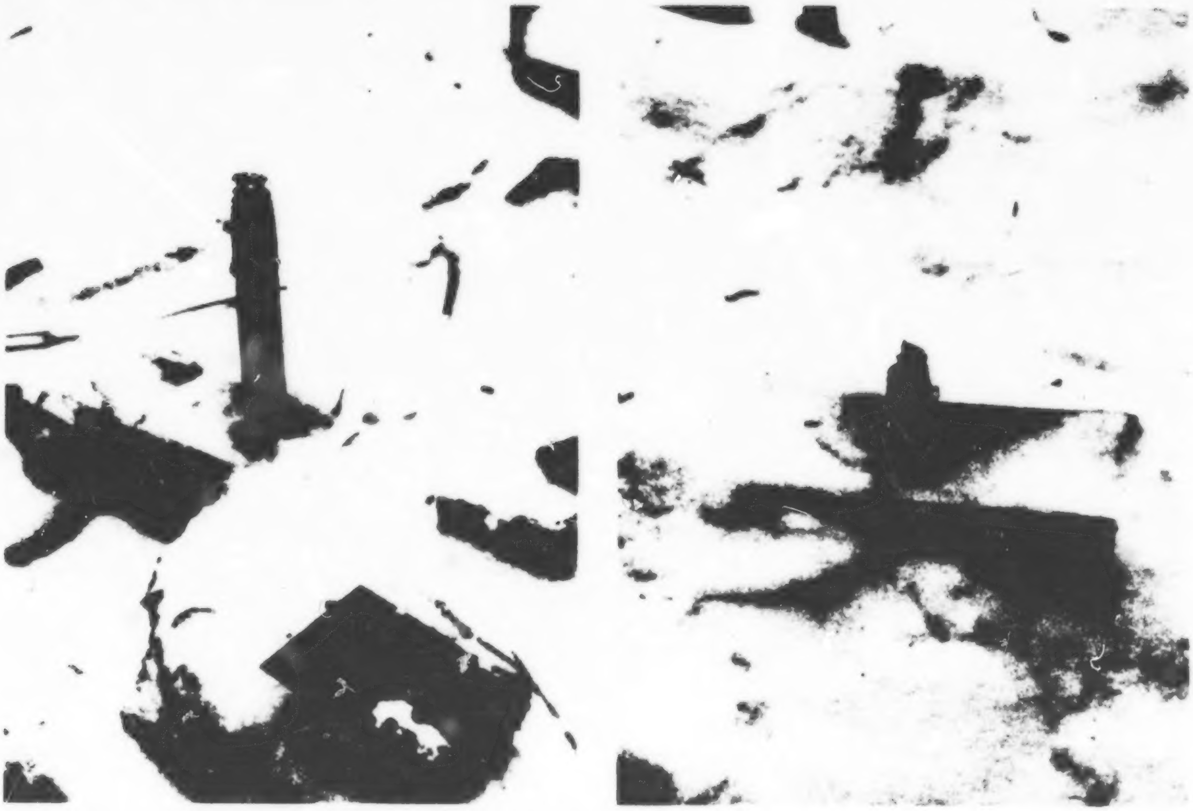


FIGURE 37

ROCK ANCHOR THREAD FAILURE
AT TWR 145 LEG 2

177495-RD
Bart 3 Disk



North Anchor Bolt

South Anchor Bolt

FIGURE 38

ROCK ANCHOR THREAD FAILURES
AT TWR 151 LEG 1

FIGURE 39

A COLLECTION OF ROCK ANCHOR
THREAD FAILURES

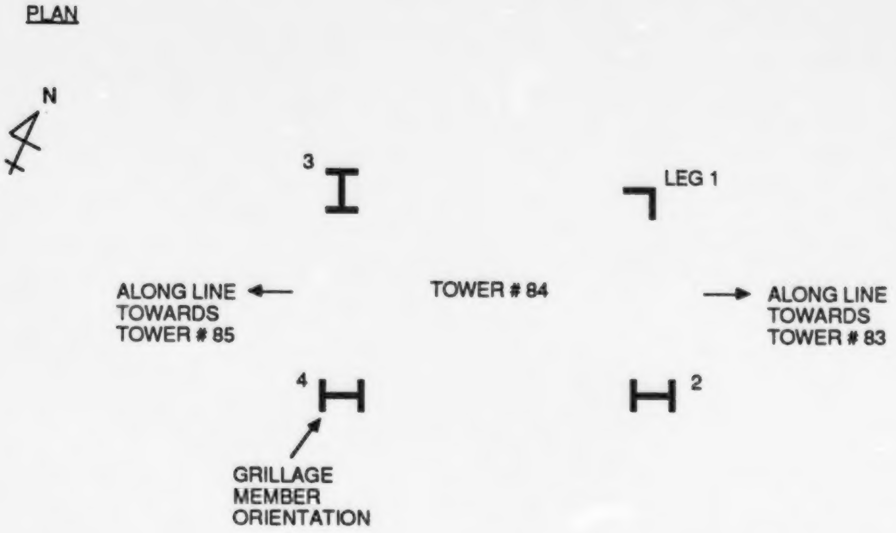
DISTRIBUTION

Mr. T.J.Carmichael	Civil Research
Dr. H.S.Radhakrishna	"
Mr. R.H.Tsang	"
Dr. D.G.Havard	Mechanical Research
Mr. J. Kalnins	"
Mr. D.G.Auston	"
Mr. D.B.King	"
Mr. G.A.Senkiw	"

Official Record

APPENDIX E

EARTH GRILLAGE


PLAN
N
3
LEG 1
ALONG LINE TOWARDS TOWER # 85
TOWER # 84
ALONG LINE TOWARDS TOWER # 83
4
2
GRILLAGE MEMBER ORIENTATION

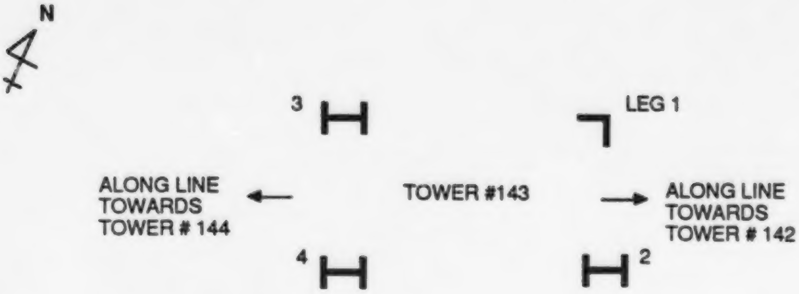
LEG #	
1 *	LATERAL SHEAR TEST AND EXCAVATED FOR INSPECTION
2	UPLIFT TEST AND EXCAVATED FOR INSPECTION
3*	EXCAVATED FOR INSPECTION ONLY
4	UPLIFT TEST AND EXCAVATED FOR INSPECTION

NOTE:

(*) MAIN TOWER LEG SLIGHTLY BENT DUE TO DAMAGE DURING TOWER REMOVAL

FIGURE E1
TOWER # 84 LAYOUT

PLAN


N
3
LEG 1
ALONG LINE TOWARDS TOWER # 144
TOWER #143
ALONG LINE TOWARDS TOWER # 142
4
2

LEG #	
1*	EXCAVATED FOR INSPECTION ONLY
2	UPLIFT TEST AND EXCAVATED FOR INSPECTION
3*	LATERAL SHEAR TEST AND EXCAVATED FOR INSPECTION
4	UPLIFT TEST AND EXCAVATED FOR INSPECTION

NOTE

(*) MAIN TOWER LEG SLIGHTLY BENT DUE TO DAMAGE DURING TOWER REMOVAL

FIGURE E2

TOWER # 143 LAYOUT

TABLE E1

TL REFURBISHMENT - SMITH FALLS
FOUNDATION FIELD LOAD TESTS

TOWER NO. 84
LEG 4
GRILLAGE

APPLIED LOAD (LBS.)	APPLIED LOAD (kN)	UPLIFT DISPL. (MM)	HOLD TIME (MIN.)
0	0	0	
2000	8.9	0.64	
3200	14.24	1.27	
4600	20.47	2.54	
6200	27.59	3.18	
6200	27.59	4.76	4 MIN.
8000	35.6	5.72	
8000	35.6	5.96	5 MIN.
8000	35.6	6.99	10 MIN.
9200	40.94	6.99	
9200	40.94	9.52	5 MIN.
10600	47.17	9.52	
10600	47.17	13.34	10 MIN.
12000	53.4	13.34	
12000	53.4	13.97	2 MIN.
13400	59.63	14.61	
13400	59.63	16.51	5 MIN.
14800	65.86	17.15	
14800	65.86	19.69	5 MIN.
16000	71.2	20.96	
16000	71.2	23.5	5 MIN.
17400	77.43	26.04	
17400	77.43	31.12	5 MIN.
18600	82.77	31.12	
18600	82.77	35.56	5 MIN.
20000	89	35.56	
20000	89	40.41	5 MIN.
20000	89	46.36	10 MIN.
22000	97.9	46.99	
23000	102.35	55.25	
0	0	38.74	
29000	129.05	100.97	
0		-	
30600		-	

TABLE E2

TL REFURBISHMENT - SMITH FALLS
FOUNDATION FIELD LOAD TESTS

TOWER NO. 84
LEG 2
GRILLAGE

APPLIED LOAD (LBS.)	APPLIED LOAD (kN)	UPLIFT DISPL. (MM)	HOLD TIME (MIN.)
0	0	0	
2000	8.9	0.64	
4800	21.36	3.81	
7400	32.93	5.08	
7400	32.93	7.3	5 MIN.
10000	44.5	8.89	
10000	44.5	10.8	5 MIN.
12600	56.07	11.75	
12600	56.07	13.97	5 MIN.
12000	53.4	15.24	
6000	26.7	13.97	
2000	8.9	12.7	
1000	4.45	12.7	
0	0	10.16	
6000	26.7	11.43	
8000	35.6	12.95	
12000	53.4	15.24	
10000	44.5	15.24	
13200	58.74	15.24	
13200	58.74	16.51	5 MIN.
16000	71.2	19.05	
16000	71.2	20	5 MIN.
18400	81.88	20.96	
18400	81.88	26.35	10 MIN.
14000	62.3	29.21	
8000	35.6	25.4	
5000	22.25	22.86	
2000	8.9	22.23	
0	0	19.05	
6000	26.7	20.57	
9000	40.05	22.23	
16000	71.2	25.4	
18200	80.99	27.94	
18000	80.1	29.21	5 MIN.
21400	95.23	32.39	
21400	95.23	37.47	5 MIN.
24200	107.69	41.91	
24200	107.69	48.9	5 MIN.
27400	121.93	50.8	
27400	121.93	54.61	10 MIN.
29400	130.83	55.25	
29400	130.83	57.79	
32500	144.625	101.6	
0	0	78.11	

TABLE E3

TL REFURBISHMENT - SMITH FALLS
FOUNDATION FIELD LOAD TESTS

TOWER NO. 84
LEG 1
GRILLAGE

APPLIED LOAD (LBS.)	APPLIED LOAD (kN)	LATERAL DISPL. (MM)	HOLD TIME (MIN.)	
0	0	0		
550	2.4475	11.71		
650	2.8925	14.01	1 MIN.	
800	3.56	15.41	3 MIN.	
900	4.005	15.96	5 MIN.	
1100	4.895	17.31		
1700	7.565	23.91	1 MIN.	
1800	8.01	26.21	2 MIN.	
1900	8.455	27.51	3 MIN.	
1900	8.455	28.71	4 MIN.	
1900	8.455	29.41	5 MIN.	
2300	10.235	33.61		
2500	11.125	40.61	1 MIN.	
2700	12.015	59.11	2 MIN.	
2900	12.905	74.11	3 MIN.	
3000	13.35	84.11	4 MIN.	
3100	13.795	92.11	5 MIN.	
3200	14.24	100.11	6 MIN.	(*)
3250	14.4625	105.61	7 MIN.	
3300	14.685	112.11	8 MIN.	
3300	14.685	115.61	9 MIN.	
3400	15.13	122.61	10 MIN.	
3400	15.13	124.11	11 MIN.	
3400	15.13	125.21	12 MIN.	
3800	16.91	133.11		
3900	17.355	143.11	1 MIN.	
4000	17.8	149.61	2 MIN.	(**)

NOTE:

A) HORIZONTAL DISTANCE OF BULLDOZER TO GRILLAGE 30 TO 40 FT.
VERTICAL HEIGHT OF BULLDOZER 4 FT.

B) STICK-UP OF GRILLAGE LEG MEMBER ABOVE GROUNDLINE 10 INCHES

C) RESULTANT OF APPLIED LOAD WAS AT AN INCLINED ANGLE OF APPROXIMATELY 5 DEGREES

D) HYDRAULIC LOAD INCREMENTALLY INCREASED DURING HOLDS

E) HORIZONTAL DISPLACEMENTS MEASURED BY DIAL GAUGE 10 INCHES ABOVE GROUNDLINE

(*) GRILLAGE ANGLE LEG TWISTED 5 TO 10 DEGREES AS NOTICED BY ROTATION OF THE CONNECTION PLATE
(**) HYDRAULIC CYCLINDER OUT OF STROKE AND PUMP OUT OF OIL

TABLE E4

TL REFURBISHMENT - SMITH FALLS
FOUNDATION FIELD LOAD TESTS

TOWER NO. 143
LEG 4
GRILLAGE

APPLIED LOAD (LBS.)	APPLIED LOAD (kN)	UPLIFT DISPL. (MM)	HOLD TIME (MIN.)
0	0	0	
2500	11.125	3.18	
5000	22.25	6.6	
7500	33.375	10.16	
10000	44.5	15.88	
10000	44.5	25.4	5 MIN.
13000	57.85	28.58	
13000	57.85	98.43	10 MIN.

TABLE E5

TL REFURBISHMENT - SMITH FALLS
FOUNDATION FIELD LOAD TESTS

TOWER NO. 143
LEG 2
GRILLAGE

APPLIED LOAD (LBS.)	APPLIED LOAD (kN)	UPLIFT DISPL. (MM)	HOLD TIME (MIN.)
0	0	0	
1200	5.34	0.19	
2000	8.9	0.69	
4000	17.8	4.11	
4000	17.8	4.12	5 MIN.
0	0	2.07	
3200	14.24	2.12	
4400	19.58	3.65	
5000	22.25	4.75	
5000	22.25	5.36	5 MIN.
0	0	3.14	
2000	8.9	5.05	
5000	22.25	5.55	
5000	22.25	6	5 MIN.
6000	26.7	6.5	
6000	26.7	7.95	5 MIN.
6000	26.7	8.22	10 MIN.
7500	33.375	8.75	
7500	33.375	10.93	5 MIN.
7500	33.375	11.31	10 MIN.
8600	38.27	11.9	
8600	38.27	13.32	5 MIN.
8600	38.27	13.55	10 MIN.
10000	44.5	14.85	
10000	44.5	18.65	2 MIN.
10000	44.5	19.65	5 MIN.
10000	44.5	20.55	10 MIN.
10000	44.5	20.88	15 MIN.
11600	51.62	23.55	
11600	51.62	31.05	2 MIN.
11600	51.62	33.35	5 MIN.
11600	51.62	35.75	10 MIN.
11600	51.62	38.75	15 MIN.
11600	51.62	40.75	20 MIN.
11600	51.62	42.25	25 MIN.
11600	51.62	44.05	30 MIN.
11600	51.62	44.45	31 MIN.
12800	56.96	47.45	
12800	56.96	57.45	1 MIN.
12800	56.96	64.45	2 MIN.
12800	56.96	77.45	5 MIN.
12800	56.96	98.4	10 MIN.

TABLE E6

TL REFURBISHMENT - SMITH FALLS
FOUNDATION FIELD LOAD TESTS

TOWER NO 143
LEG 3
GRILLAGE

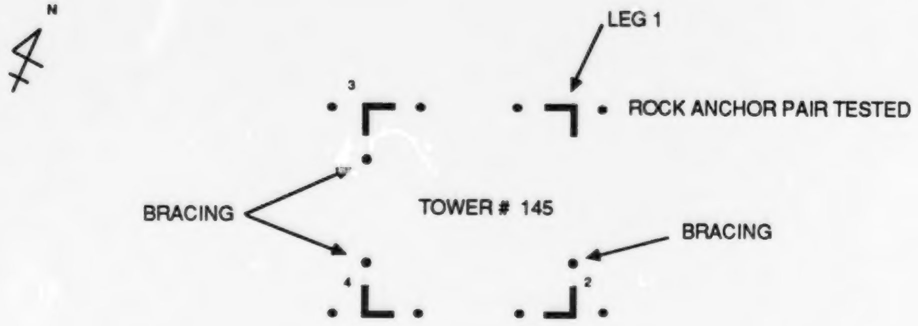
APPLIED LOAD (LBS.)	APPLIED LOAD (kN)	LATERAL DISPL. (MM)	HOLD TIME (MIN.)
0	0	0	
950	4.2275	29.56	
1150	5.1175	32.21	
1150	5.1175	36.1	1 MIN.
1150	5.1175	38.41	2 MIN.
1150	5.1175	39.31	3 MIN.
1150	5.1175	40.31	4 MIN.
1150	5.1175	40.81	5 MIN.
1150	5.1175	41.31	6 MIN.
1200	5.34	41.71	7 MIN.
1200	5.34	41.91	8 MIN.
1200	5.34	42.2	9 MIN.
1200	5.34	42.37	10 MIN.
1500	6.675	45	
1600	7.12	55	1 MIN.
1700	7.565	60	2 MIN.
1800	8.01	63	3 MIN.
1800	8.01	70	4 MIN.
1800	8.01	80	5 MIN.
1900	8.455	84.5	6 MIN.
1950	8.6775	87.5	8 MIN.
2000	8.9	90.5	9 MIN.
2000	8.9	92.8	10 MIN.
2000	8.9	95	11 MIN.
2000	8.9	96.5	12 MIN.
2000	8.9	97.5	13 MIN.
2000	8.9	98.4	14 MIN.
2000	8.9	99.2	15 MIN.
2000	8.9	100.4	17 MIN.
2200	9.79	102	
2200	9.79	106.5	1 MIN.
2200	9.79	109	2 MIN.
2300	10.235	111.1	3 MIN.
2300	10.235	113.3	4 MIN.
2300	10.235	114.5	5 MIN.
2300	10.235	116	6 MIN.
2300	10.235	117.9	7 MIN.
2300	10.235	119.4	8 MIN.
2300	10.235	120.7	9 MIN.
2300	10.235	122.3	10 MIN.

NOTE:
A) HORIZONTAL DISTANCE OF BULLDOZER TO GRILLAGE 30 TO 40 FT.
B) VERTICAL HEIGHT OF BULLDOZER 4 FT.
C) STICK-UP OF GRILLAGE LEG MEMBER ABOVE GROUNDLINE 6 INCHES
D) RESULTANT OF APPLIED LOAD WAS AT AN INCLINED ANGLE OF APPROXIMATELY 6 DEGREE
E) HYDRAULIC LOAD INCREMENTALLY INCREASED DURING HOLDS
F) HORIZONTAL DISPLACEMENTS MEASURED BY DIAL GAUGE 6 INCHES ABOVE GROUNDLINE

APPENDIX F

ROCK ANCHORS

PLAN


N
LEG 1
3
ROCK ANCHOR PAIR TESTED
BRACING
TOWER # 145
BRACING
4
2

LEG #	
1*	ROCK ANCHOR FOUNDATION EXPOSED ABOVE GROUNDLINE
2*	ROCK ANCHOR FOUNDATION EXPOSED ABOVE GROUNDLINE
3	ROCK ANCHOR FOUNDATION BURIED UNDER 15 cm OVERBURDEN
4	ROCK ANCHOR FOUNDATION BURIED UNDER 15 cm OVERBURDEN

NOTE

(*) UPLIFT LOAD TESTS PERFORMEFD ON LEFT AND RIGHT ROCK ANCHOR

FIGURE F1

TOWER # 145 LAYOUT

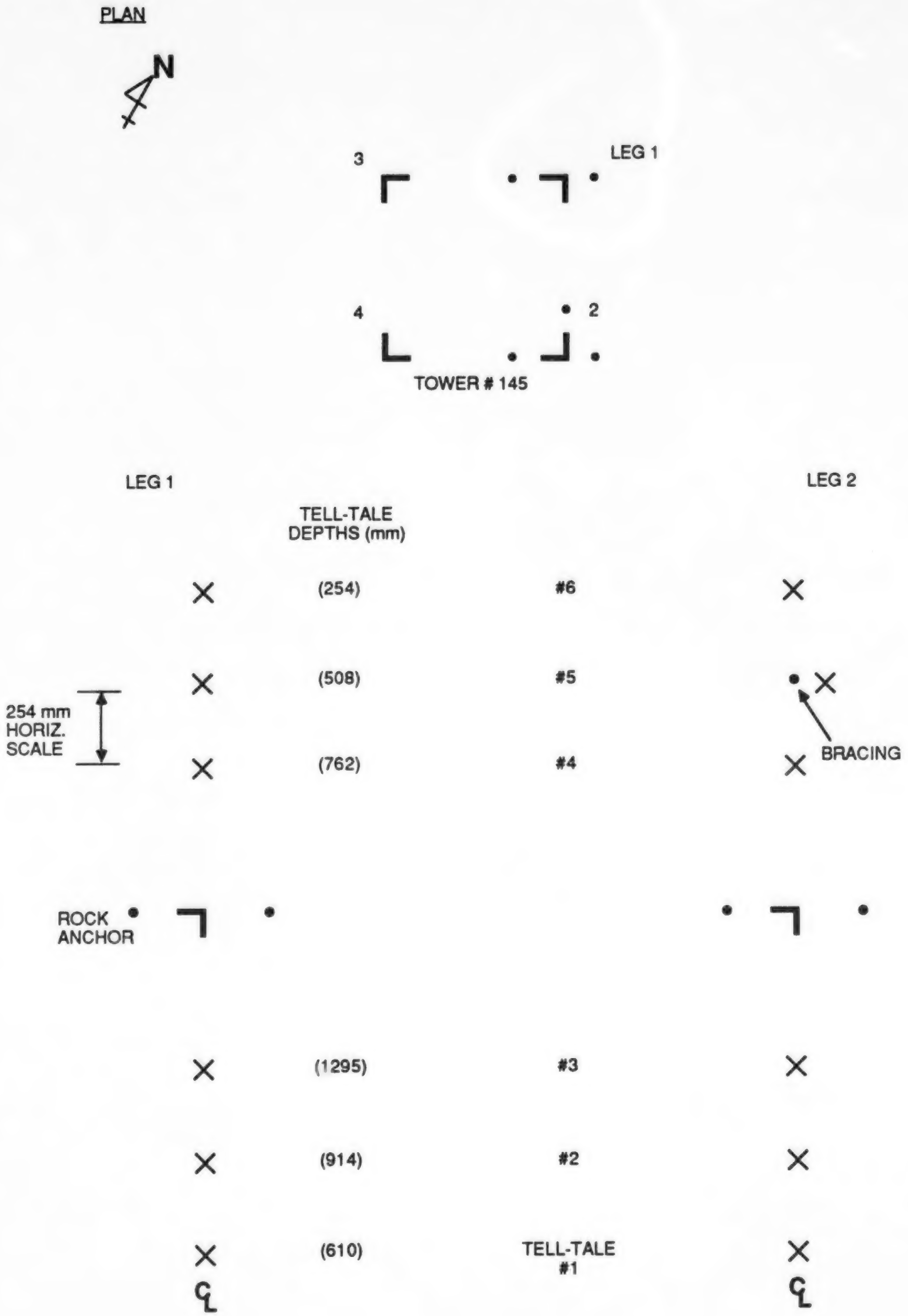
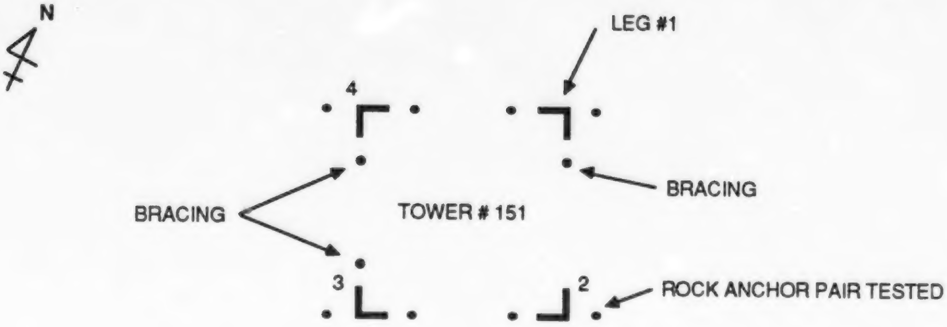

PLAN
N
3
LEG 1
4
2
TOWER # 145
LEG 1
LEG 2
TELL-TALE DEPTHS (mm)
(254)
#6
(508)
#5
254 mm HORIZ. SCALE
(762)
#4
BRACING
ROCK ANCHOR
(1295)
#3
(914)
#2
(610)
TELL-TALE #1
CL
CL

FIGURE F2

INSTRUMENTATION AT TOWER # 145

PLAN


N
LEG #1
4
BRACING
TOWER # 151
BRACING
3
2
ROCK ANCHOR PAIR TESTED

LEG #	
1	ROCK ANCHOR FOUNDATION EXPOSED ABOVE GROUNDLINE
2	ROCK ANCHOR FOUNDATION EXPOSED ABOVE GROUNDLINE
3	ROCK ANCHOR FOUNDATION BURIED UNDER 15 cm OVERBURDEN
4	ROCK ANCHOR FOUNDATION BURIED UNDER 15 cm OVERBURDEN

NOTE

(*) UPLIFT LOAD TESTS PERFORMED ON LEFT AND RIGHT ROCK ANCHOR

FIGURE F3

TOWER # 151 LAYOUT

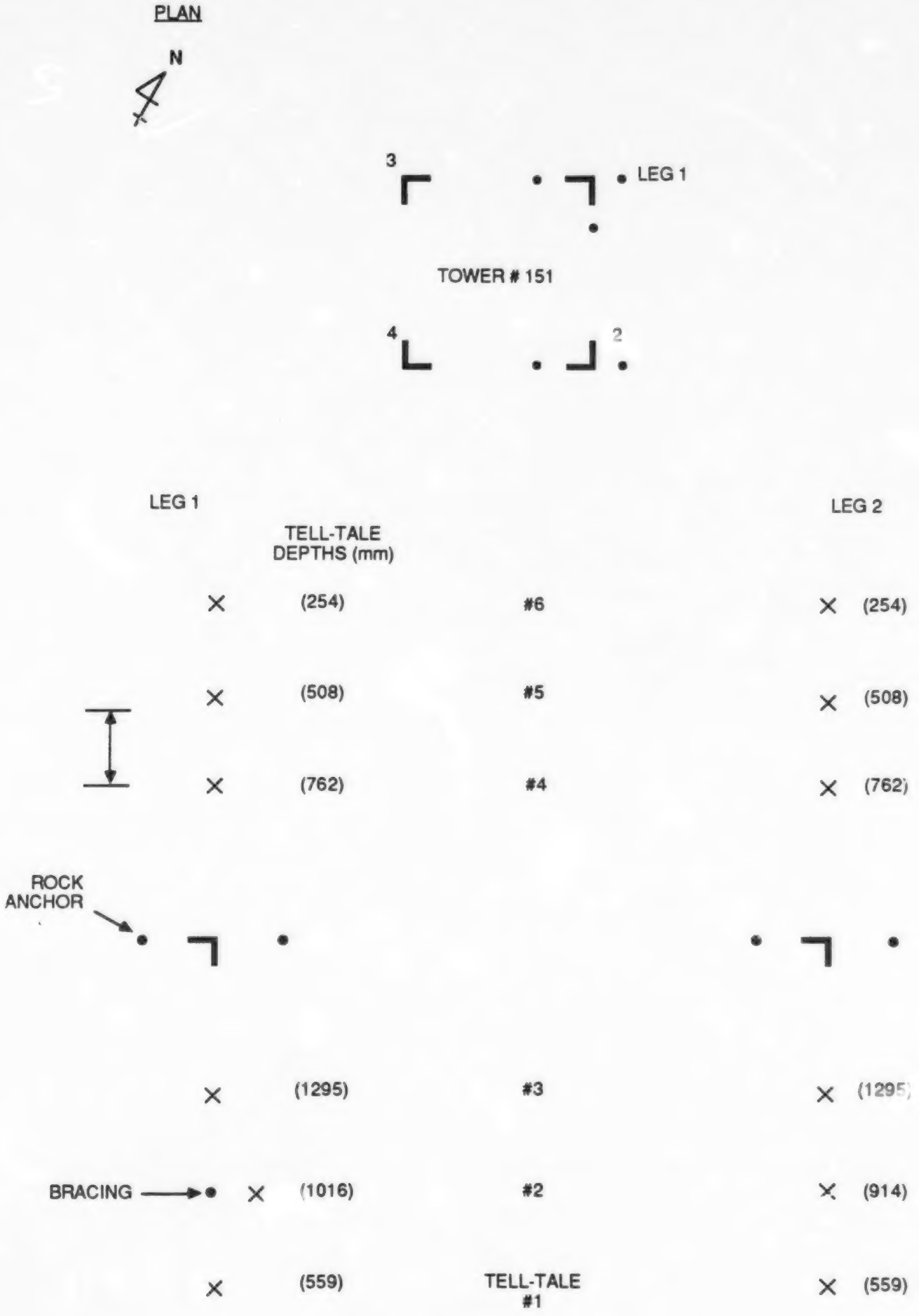

PLAN
N
3
LEG 1
TOWER # 151
4
2
LEG 1
LEG 2
TELL-TALE DEPTHS (mm)
(254)
#6
(254)
(508)
#5
(508)
(762)
#4
(762)
ROCK ANCHOR
(1295)
#3
(1295)
BRACING
(1016)
#2
(914)
(559)
TELL-TALE #1
(559)

FIGURE F4

INSTRUMENTATION AT TOWER # 151

JA-TSANG 6
JA 6 DISK